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The Waterways Problem.

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The report of the Inland Waterways Commission, appointed by the President in March of 1907, again calls attention to the urgent need of some drastic measures which will relieve the country from the inadequate facilities for the removal of the enormous tonnage which the nation produces. In referring to the report in his message the President characterizes it as the conservative, sane and just judgment of a body of exceptionally well qualified experts, and adds that if it errs at all it is by over-conservatism. "The subject of which it deals is of critical importance, both to the present and to the future of our country."

Being in full accord with these sentiments and realizing the urgency of a speedy conclusion which shall make provision for the opening of the magnificent systems which the United States affords for internal transportation by water, it seems appropriate

to review briefly the actual situation and the remedies suggested, not in a spirit of criticism, but with a view to an early remedy.

Although the rivers have continued to flow to the seas for many centuries and projects have been on the tapis for generations, he has aptly said that "*The rivers of no other civilized country are so poorly developed, so little used, or play so small a part in the industrial life of the nation as those of the United States.*"

The reasons for this condition are ascribed largely to "unregulated railroad competition," which has tapped the traffic at its origin and confined it to wheels, whereas it is abundantly shown by experience in all countries that the proper segregation of the bulky freights to the water routes is the best for all interests, and the greatest masters of transportation and students of economics have for many years been attempting to effect such a separation to prevent the engorgement which has been so manifest in the past.

HISTORY REDIVIVET. SECTIONALISM.

But there are other causes of great potency also which have caused the decadence in the water-borne traffic. Prior to the advent of the railroad as a competitor, there were numerous private companies chartered by the States for the improvement of the waterways as commercial enterprises, authorized to build, operate, and maintain navigable waterways, whether as canals or slack-water rivers, to sell the power stored in the dams and to charge tolls. Under these rights some 5,000 miles of canals were constructed prior to the Civil War at a cost of about $150,000,000, or an average of $30,000 a mile. A century ago the sparse population and limited capital of the States appeared to be insufficient for the great work of connecting the Great Lakes with the seaboard and the "Empire State" solicited the aid of the Nation in the form of a land grant to build the Erie Canal, but after a long discussion and many flattering promises it was finally refused because of the sectional jealousies which led the Commissioners to report to the New York Legislature, in 1811, that:

"On the 21st of December, they waited on the President of the United States (Monroe) and found him, although he expressed himself to be an enthusiast as to the advantage of interior navigation, by means of canals, embarrassed by scruples derived from

his interpretation of the constitution. At the close of their visit, however, he was in better disposition, which is evidenced by his message to Congress, of the 23d of December, copy whereof is annexed. On the 24th they attended at the Treasury office and found the Secretary desirous of performing this, and other works of a similar nature, conformably to the plan which he had reported at the precedent session. He was under the opinion that under present circumstances, pecuniary aid would not be given; but that sufficient grants of land might be made now without inconvenience to the fiscal concerns of the Union.

"Your committee found an idea prevailing with some, and sedulously inculcated on others, that it would *be wise so to amend the Constitution*, as expressly to authorize the general government to incorporate banks and *make roads and canals without the consent of the States.*

"This suggestion arose, they believe, from the desire to resuscitate the national bank. * * * Other objects were introduced rather as a convenient cover than as needful concomitants. Whatever may be the case with respect to banks, the proposed amendment, so far as regarded roads and canals, appeared to your committee to be worse than useless. * * * Your committee felt it a duty to declare, on all proper occasions, a decided opinion that the States *would not consent to vest in the National Government a power to cut up their territory, for the purpose of digging canals.*

"Your committee found another idea operating with baleful effect, though seldom and cautiously expressed. The population and resources of the State of New York furnish no pleasant reflection to men, whose minds are imbued with State jealousies; and although the proposed canal must not only be of the highest importance to the western States, as well as to the States of Pennsylvania and Maryland, and greatly promote the prosperity of the whole Union, it was obvious that an opinion of its superior benefit to this State was sedulously inculcated. An opinion which there is reason to fear will have too much influence in every consideration of this subject. * * *

"It became evident that the object of this State would not be separately attended to and your committee were desired to prepare a general system * * * they had learned, in the course of their conversation with individuals, that unless something was

*Italics by author.

done for many of the States, the consent of the majority of the House of Representatives could not be obtained." * * *

Thus a log-rolling bill covering a system of canals in most of the States of the Federal domain lying east of the Mississippi, was draughted, and it provided for the appropriation of 9,900,000 acres among the several States, of which New York's pro rata was to have been 4,500,000. The objection, however, was so great that the bill was smothered in sub-committee and New York was compelled to carry on the work from her own resources, thus securing for herself the commercial supremacy of the western world and leaving her sister States without the Federal assistance and internal development they might have secured so readily but for the narrow sectional policy which was permitted to prevail.

In closing their report the commissioners stated:

"Others, again, who have too much understanding to doubt the resources of the State, and too much prudence to expose themselves to ridicule, by expressing such doubt, triumphantly declare, that her Legislature has not the spirit and intelligence to draw out and apply her resources to that great object.

"These men console themselves with a hope that the envied State of New York will continue a suppliant for the generosity of the Union, instead of making a manly and dignified appeal to her own power. It remains to be proved, whether they judge justly who judge so meanly of our councils."

The sequel proved the wisdom of the commission in abandoning further efforts to secure national aid, and these extended extracts may point the moral which has been so oft repeated in subsequent years, of the difficulty in securing enabling legislation for the most important and meritorious national improvements, because of petty jealousies or sectionalism. It follows that under the general provisions of the Constitution and the practice existing prior to the war, that the system was working very satisfactorily and that facilities were created whenever and wherever the prospects seemed to justify a fair return on the capital, whereas at present, private capital is being paralyzed by the inhibition of tolls on waterways, while it has ever been permitted on the railroads, without which they could not exist, and the efforts to regulate the tariffs by legislation is having a direful effect. The rehabilitation of the waterways on a commercial basis would go far

to relieve the railway, while it would also add largely to its more profitable business at less cost for plant and operation.

Thus history is constantly repeating itself, but the lesson of experience appears to be lost in the ever changing personnel of the actors in the legislative and executive departments of the Government.

The present régime and the obligation under which the Government is now laboring are well stated by Senator Philander C. Knox, of Pennsylvania, in his address to the Chamber of Commerce of Pittsburgh, on February 12th, when he said:—

*"The duty of the Government to raise its waterways and harbors to their utmost efficiency was determined long ago by the action of the Government itself. * * * It invited cities to improve their docks to accommodate large ocean vessels. It held out inducements to railways to bring their tracks to the water's edge and construct terminals for the transfer of freight from cars to vessels. So when the Government assumed charge and control of the navigable streams of the interior it entered into a practical contract with the States and communities bordering these streams that their waterways would be improved to their highest capacity. The States were thereby prevented from improving the streams themselves. Corporate enterprise was forbidden to undertake the canalization of important stretches and fix the cost of their works and franchises on the traffic. The Federal Government has made its formal and deliberate declaration that it will do this work. That necessarily involves that it will make the improvements adequate to modern needs and possibilities. To do any less would be a mockery and breach of good faith."*

DEFECTS OF THE SYSTEM.

How has the Government fulfilled this duty? Let the President in his courageous and forceful message answer. He says, as already quoted, that *no rivers of any other civilized country are so poorly developed as our own.* If we look for the reasons, outside of the great interests vested in the "rival" carriers which have found it simpler and cheaper to regulate legislation than to purchase and destroy canals, we will find that the complaint is made of the wholly inadequate appropriations for the rivers and harbors

of the country. Even to-day with the great enthusiasm and thorough organizations existing from Maine to Texas and the universal demand for relief, the policy of Congress is not to pass a bill, and thus the paralysis continues while tentative works are encouraged in isolated localities notwithstanding the strenuous efforts of the committees to secure continuous appropriations for the trunk lines of traffic, and even new works are authorized in inaccessible districts where there is no commerce because of the great dangers surrounding the approaches. But is this complaint well grounded?

LACK OF INITIATIVE AND OPPOSITION BY GOVERNMENT.

In the first place although, as Senator Knox has stated, the Government has assumed the jurisdiction of all waterways or those that may be made navigable, it does not take the initiative in originating their improvement, and it is left for the localities interested to send their committees to Washington, and in many cases to retain permanent solicitors at the capital to further their interests. Thus all sections are arrayed against one another and allied with other adverse interests, and because of the demands for large appropriations for less imperative departmental services, these vital works are postponed from time to time, amounting to generations, and without national aid or consent the localities are deterred from inaugurating improvements of their own.

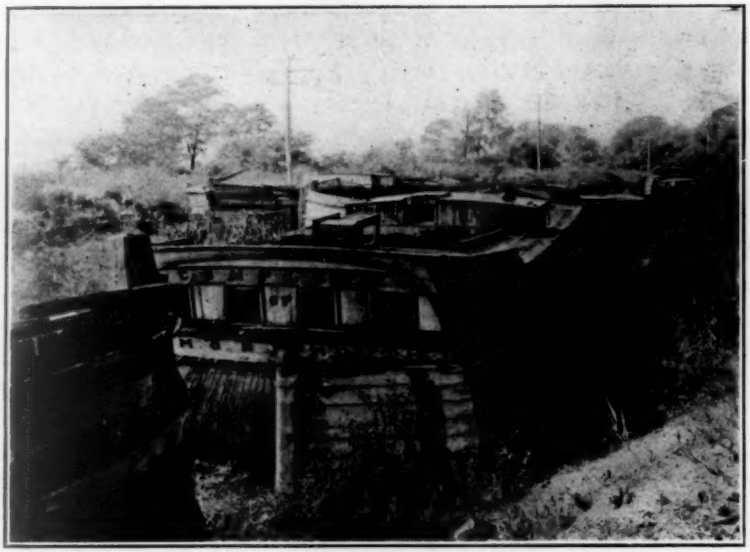
Not only was the Erie Canal thus opposed, but the Sault Ste Marie, the greatest portage on earth, was objected to in Congress as being "beyond the pale of civilization if not in the moon." Yet no expenditure made by the United States of equal amount has returned so vast a profit to its people or done more to promote their welfare.

The Louisville and Portland Canal was also opposed by the Government in the early part of the last century, and was finally started under a charter from the State of Kentucky issued in 1825, and built by a stock company, which subsequently released it to the United States at a large profit to the latter after earning $1,200,000 more than its entire cost.

The Delaware and Raritan, the Morris and Essex, the Schuylkill and Susquehanna, the James River and Kanawha, the Chesapeake and Ohio, and in fact practically all of the canals in the

country were built by private capital under State charters and without aid from the Government.

Since the advent of the railroad they have been purchased and exterminated to such an extent that less than fifty per cent. of the mileage has survived, and these are too small to meet the demands of modern traffic without a thorough reconstruction. Some of the wreckage of the Pennsylvania canals is shown in Fig. 1, and is indicated by the very name of the boat, which is "Complete."



APPROPRIATIONS AND RESULTS.

A brief digest of the expenditures of the Government upon our rivers and harbors will serve to throw some light upon the efficiency of these works, regardless of the abstraction of the traffic by the railways and the great increase in the dimensions of vessels which demand channels of much greater capacity.

Up to the beginning of 1867, the total expenditures by the Government for rivers and harbors was $14,994,206.63, and yet the canal and slack-water systems had been built and were well maintained, while, since that date, the expenditures for these improvements have aggregated $559,909, 090, and the results are charac-

terized by the Chief Executive as "largely negative." "No single agency has been responsible under the Congress for making the best use of our rivers, or for exercising forethought in their development. In the absence of a comprehensive plan, the only safe policy was one of repression and procrastination. * * * In spite of large appropriations for their improvement our rivers are less serviceable for inter-state commerce to-day than they were half a century ago, and in spite of the vast increase in our population and commerce they are on the whole less used."

This pregnant paragraph contains much food for thought since it is during this period of "repression and procrastination" that these works have been almost exclusively under the control of the War Department, whose officers are prohibited by virtue of their duties and training, as well as from their temporary details at various stations and the absence of individual responsibility for the plans, from inaugurating or recommending any project; while it not infrequently happens that they are responsible for the approval of the plans for the structures over or under navigable streams designed by the common carriers who desire to retain the tonnage by blocking the waterway, which purpose would seem to have been accomplished by the statement in the report of the Commission that among the reasons for the decline of river traffic was "the adverse placement of tracks and structures, and by various other means." This is confirmed by the fact that instances are numerous where permanent steel girders or stone bridges have been erected over waterways, presumably by authority of the War Department, at so low an elevation as to debar even coal barges from supplying mills and factories with their fuel, formerly received by water, and placed upon navigable streams because of that possibility.

This bureau, which has had control of the works and plans during all this time, is perhaps unfortunately the only one which can be held accountable for the present conditions of the waterways, and after so many years of management it may be of interest to hear what the Mississippi River Commission has to say with reference to the improvements of that great drainage and navigation system to which His Excellency refers, as having at one time no rival in any country for the traffic, which has to-day almost vanished from its surface.

In the official report for the year 1903, the Commission states:

"Systematic work, which has for its object to permanently locate and deepen the channel, has not been practicable under existing conditions. In the limited extension and repair of bank protection and contraction work the Commission has, however, kept in mind that the permanent improvement of the river is contemplated by the organic act, and experiments are continually being made looking to the best use of available material and the development of appliances and methods which may be economically and effectively employed when Congress shall provide for such systematic improvement." All of which appears to imply that notwithstanding the "large appropriations for their improvement," the Commission is still unable to show any definite results until Congress shall make them still greater. But it seems that the levee system has grown enormously in height, length and breadth, and that this irregular enceinte has not had any material effect in the improvement of the channel. On this point the distinguished and patriotic ex-Senator from Arkansas, Senator Berry, said: "Under the Constitution, Congress had no power to appropriate money to protect private property. I want to say to-day that every dollar that has ever been appropriated for levees on the Mississippi River has been on the theory that it would benefit navigation, and we never dared to put it on the ground, up to this day, that it would benefit private landowners, though we knew of course that it was incidental to it."

The statement was also made freely that the effect of this protection from overflow was to advance the value of the low swamp lands as well as the uplands "all over the alluvial valley, in some places 100 per cent., in some places 200 per cent., in some places 300 per cent.," thus showing the almost irresistible inducement for large appropriations from the national treasury and their application to the construction of the levees which produced negative results upon the navigability of the low-water stages and compelled the resort to hydraulic dredges to remove the additional mud thus confined to the bed of the valley and which formerly escaped to enrich the plains and reclaim its swamps.

That the policy of "repression and procrastination" is still prevalent, is also manifested in the rules adopted by Congress prohibiting appropriations prior to a survey, although it frequently happens that all necessary data are on file in the Government offices, but by this means the works can be forestalled, from two to three

years, and the funds be applied for other purposes while the country waits, or, it may be that in the absence of definite plans and the necessity for keeping up appearances or to exclude some proposition which may be guaranteed to give the requisite channels, which other interests may not desire, the appropriations may be recommended and the contracts let in such manner as to permit of changes of plans as the difficulties are developed during the process of the work. Under this policy the proposals of Capt. Jas. B. Eads, and others, for the improvement of Galveston Harbor, the Southwest Pass, the Aransas Pass, the mouth of the Columbia River, New York entrance and other important places were rejected and many of them suppressed from the official reports to Congress. The story of the delta of the Mississippi has almost reached a crisis. After Eads was remanded to the South Pass, which is no longer equal to the demands of the traffic of the great river, the Government engineers submitted a plan for the opening of the Southwest Pass, at an estimated cost of $13,000,000 for two parallel, straight jetties. Congress was not very favorably impressed with it, since a large portion of this work was out of the water and on the marshy banks of the river, or else in deep holes of twenty or more feet, close beside the natural banks, so that a revision was ordered to meet the offer of responsible parties to create a thirty-five-foot channel, and guarantee the results, for $6,000,000.

A Board of Engineers abandoned the original plan and reported in favor of a bottle- or coffin-shaped arrangement of jetties, placed so far back from the river bed as *"to take from them the duty of forming the channel"* and placing the *"main reliance upon dredging."* The results to be expected from this plan, with the enormous quantity of silt, amounting to over 100,000,000 cubic yards annually, which the Pass was carrying to the Gulf, was pointed out to the Board by the parties making the guaranteed proposal, but this merely resulted in a hasty modification of the location of the jetties and an appropriation for the construction on the proposed plan, of which it was stated in the report to Congress that "No contract for the superstructure should be made until experiment and experience have developed the most economical methods of construction." Also, "The construction engineer should be free, subject, of course, to the approval of the Chief of Engineers, to modify them (the plans) in all particulars, as experience may dictate."

Such were the conditions under which work was undertaken at the mouth of this sedimentary delta, with numerous precedents as a guide, and the main reliance was to be on dredging between jetties which had no duties to perform as channel formers. The work as to the jetties is now reported as completed and two hydraulic dredges have been constantly engaged in the efforts to cope with the sediment, with the result that the ruling depth is reported at twenty-two feet and the crest of the new bar is about a half-mile outside of the jetties, which have scoured a hole far deeper, between their outer portions, than was required for the channel, extending to over eighty feet, the material from which has been added to the bar beyond, and the jetties are now to be extended into the Gulf, thus flattening the slope of the river and increasing the heights of the floods and danger from crevasses.

Many such instances of tentative plans may be cited, but suffice it to point out one of a purely tidal entrance with a feeble diurnal tide upon which a Board reported in 1887 as follows:

"The problem of the improvement of the navigation of this pass (Aransas Pass, Texas) is by no means an easy one. Some of the difficulties may be mentioned, viz.: The want of stability in the position of the pass itself, which is constantly and rapidly moving under the influence of causes—winds, waves and currents—of which the action cannot be prevented and the effects only measurably neutralized; the instability of the foundations on which any structure is to be built; the shifting sand of the Texas coast, the presence in the water in which any structure must be placed of the sea-worm in such activity that wood cannot be used except to a very limited and exceptional extent, if at all; the necessity of bringing stone, cement, etc., from long distances and at much expense; the heat and other discomforts of a tropical climate increasing the cost of labor." * * * "As the work progresses experience will probably suggest variations of detail. There is good prospect of success in deepening the channel by the use of the jetties. The location of those recommended (by the local engineer) is approved, subject to such change as further study may show to be expedient." * * * "No work should be begun unless there be on hand for expenditure a sum not less than $500,000."

Although this report was approved by the six members of the Board of Engineers, one of them dissented the next day and wrote

that he believed "one jetty would suffice at this locality," and that he "did not coincide with the views expressed in the report of the local engineer either in general application or in particular at this locality." It may be well to state that the local engineer had had but a limited experience in tidal waters prior to that date.

Under the above stated conditions and the tentative nature of the plan it would seem futile to even suggest a remedy in this case, and although the efforts made by the Government to secure even twelve feet had been a signal failure, yet subsequently private parties did submit a guaranteed proposition to create a twenty-foot channel for about one-fourth of the Government's estimate. This plan was finally taken over by Congress, as set forth in the

February number of the Franklin Institute *Journal*, and after many and serious delays and great opposition, completed in part, as shown in the illustration herein (Fig. 2), with the result of securing depths of over twenty feet along the completed portion, reaching even to twenty-six feet as a maximum, by the natural action of the currents and without dredging, yet, as shown, the Government has not permitted sufficient time to elapse for the currents to complete the channel, nor would it expend the petty sum of $6,000 to hasten the formation of the channel under the adverse conditions of an exceptional summer, but it has appropriated over a *million* dollars to return to the temporizing method of experimentation with two jetties to maintain an artificial chan-

net to be created subsequently by dredging at an annual cost of $75,000. This is but another flagrant reason why the President seems to be fully justified in the statements he makes as to the necessities for reorganization and cöoperation in the formulation of a systematic plan for the conduct and control of the waterways of this great federal domain.

THE "NO TOLL" FALLACY.

There is somewhere an idea prevailing which has been sedulously impressed upon the public mind that *all* waterways should be free.

This is true, however, only of certain public waterways built at public expense, but had this policy prevailed from the days of the independence of the United States, where would our waterways have been in the past, and if we are not to begin any project "until the funds necessary to complete it promptly are provided and no plan once under way should be changed except for grave reasons," how soon will our internal systems be opened? The experience of legislation in the past forty years will serve to show the utter impossibility of securing the appropriations or the plants which will meet the emergencies. The plans at Panama, exploited as thoroughly as ever any engineering work was or could be in the century of investigation, are being constantly changed to meet new conditions, especially those due to enlarged capacity of vessels, which were not foreseen. The prohibition of tolls must of necessity debar many of the minor but important local projects from being undertaken by States or localities and thus check the commercial streams at their sources and play into the hands of the very interests which have so long swayed the destiny of the country in regard to traffic by restricting the growth of the cheapest known means of transportation. In the humble opinion of the writer, this error of requiring all projects to be first approved by the general government and the prohibition of tolls as a legitimate return for the expenditures of private capital in the development of the resources of the nation, would be a most serious detriment to all interests, and a violation of the fundamental principle upon which all transportation companies are based, namely, the right to collect a reasonable compensation for moneys expended for services rendered the public, by private or local interests. Such in-

hibition would debar the States from their sovereign right to grant charters to such companies and deprive the States from their usufruct from any royalties or franchises which said States may see proper to authorize for the benefit of their own citizens, which rights and powers were distinctly reserved by "the people" in the framing of the Constitution, but they seem to have been "assumed by the Government," as stated by Senator Knox.

But it is well to reserve and exercise the right to limit the terms of such corporate powers and to provide means for emancipating the avenues of trade from the tolls, so soon as the originators may have been recouped for the outlay or the tolls become a burden in restraint of inter-state commerce. It may be germane to inquire whether the Panama Canal is to be exempt from tolls when completed, and if so, is the expenditure so largely in behalf of foreign nations justified while our domestic waterways are denied the vitalizing appropriations? Is the Suez Canal free? No. Why not? for it has paid for itself many times over.

In short, the system which would appear to furnish the most speedy relief would be approximately one which would confine the national appropriation to the trunk-line waterways for inter-state commerce; such as applies to the great rivers, the lakes and the intercoastal systems, with the important harbors of the lakes and the seaboard and such canals as constitute necessary links in the great chain of internal communications, for which a liberal minimum of draught should be fixed and the works be placed under permanent, resident and division engineers, who should be held strictly accountable for results, as was outlined in the legislation as proposed in the Cullom-Breckinridge bills of 1886-7. These should be amended, however, to meet present exigencies and to eliminate the need of special legislation as far as possible in the inauguration and conduct of these works.

COMMISSIONS VS. INDIVIDUAL RESPONSIBILITY.

During the inception of the plans and their evolution to a completed project a commission of experts may be of great value, especially where many subdivisions of science and art are involved; as hydraulics, sanitation, mechanics, electrics, organization, finance, administration, etc., yet these requisites are not always simultaneous but arise in sequence and after a general

project is well matured it would seem best to refer the details to some one or more responsible individuals to work out as the local exigencies may demand. Thus is avoided the generalization and shifting of responsibility which invariably accompanies the ever changing personnel of a Board composed of men whose succession in office or change of station necessitates rotation in duties, and lack of familiarity with details which are often vital, while experiments and changes of plan are expensive and frequently unnecessary, if the problem is well exploited in advance. Moreover, the removal of a competent official by reason of an age limitation at a time when his experience is most valuable is opposed to good policy.

The various isthmian canal commissions and the conflicting plans and estimates which they submitted will serve to illustrate the difficulty of securing the most direct results from a large body of experts, so that it has been found necessary to reduce the personnel until it is now a minimum, and the work is progressing rapidly under the admirable system which has been developed on the isthmus in the past few years.

It is true that there are many factors incidental to the development of navigable channels, such as the amount of rainfall, the rapidity with which the excess reaches the stream, the topography of the district, the extent of its forests, the character of its soils, its stratigraphy, the extent of its drainage basin, the obstacles which beset its discharge, the alignment of the path and the character of its outlets and tributaries. Some of these elements are so remotely connected with the mere question of capacity of channel for navigation that it would seem greatly to complicate the issue, to involve the prompt relief from obstructions, in a general consideration of all these collaterals. River regulation is one of canalization and preservation of uniformity of flow as well as of the abstraction of sediment from the bed, either by prevention at the intakes, relief at outlets, or removal and impounding *en route*.

These are questions pertaining to the profession of the civil and hydraulic engineer, the general principles of which are readily understood and applied, and what it immediately desired is not elaborate research into the intricate, complicated relations of trade or commerce by various media so much as the enabling legislation and release from the restrictions which have of late impeded the

free application of local resources to the creation of better transportation conditions. Even now contracts are being taken for vessels of 1,000 feet length and forty feet draught—yet there are few harbors in the world where such a steamer can berth beside the dock.

Judging from the results secured by the Bureaus of Irrigation and Forestry it would seem that the present organizations are working very effectively and harmoniously under their executive heads and that the work done tends incidentally to the conservation of both the water and sediment to keep the latter from the stream-bed and retard the flow of floods, for the benefit of navigation during low stages. The establishment of reservoirs for irrigation or for power will incidentally restrict the storm flow, as do the great Alpine lakes of Switzerland, and discharge the clarified effluent for navigation or for domestic or manufacturing purposes.

The question of the sale of the power thus stored within the States or territories, by the Government, is one which must be left for adjustment in future, but like many others of similar import, it can better afford to wait than can the more urgent, nay even vital one of the navigability of the streams.

OBSTACLES TO DEVELOPMENT.

From this brief review of the situation it appears that the main causes which have resulted in the decadence of the waterways of this nation and the traffic upon those that still remain in service are:

1. The growth of railways and the attempts of legislators to tax their tonnage in support of their competitors, the canals, previously chartered.

2. This led to reprisals to exterminate the waterways, resulting in the focussing of their control in a single legislative body at the national capital where the situation could be more readily handled and where the river and harbor, as well as many other bills, were made subordinate to the policy of the regnant administration under the Committee of Rules, which in turn is appointed by the Speaker. A consequence of this mechanism was a delay in the opening of a canals across the isthmus of Darien for nearly a century after the first American company had been chartered

for the purpose. Also the postponement of work upon the Hennepin and other canals for many years, as well as the delays in the improvement of the Ohio, Mississippi, and other rivers, because of the pressure from antagonistic interests, which could be so readily applied, to defeat legislation, on the pretext of economy or more urgent use of funds.

3. These forces were also allied to local and sectional jealousy which demanded an equal share in the distribution of the public patronage, as a consideration for approval, and hence the admissions frequently made that the small appropriations for isolated improvements were necessary to secure the passage of the bills.

4. A fourth cause is the fact that the Government does not take the initiative in making any improvements and often goes so far as to oppose the inauguration of much needed new work and of prohibiting localities from undertaking it at their own expense. In fact, one of the officers of the Corps of Engineers made the significant statement as to the reason for lack of progress that "We are forbidden, and properly so, from urging appropriations for new works, and are limited solely to giving our views and estimates, when asked to do so, by the proper authority."

One may well wonder how soon all the work of this great country, with its extended insular possessions, would be improved if the head of the Department at Washington must first initiate an inquiry as to what may happen to be needed in some remote part of the federal domain and the report must be transmitted through a succession of local officers and Boards, for examination, report, and final approval by a single individual before even an appropriation may be requested from the national treasury for a survey, while the local interests, if not restricted, would have successfully completed the work in many cases at their own cost, pending this circumlocution. Neither the Erie Canal nor the Sanitary District Canal of Chicago would have been built but for the State initiative, and many other States are to-day organizing improvement associations for the immediate completion within their borders of their own lines of traffic by water, by reason of their necessities.

5. Another cause may be found in the onerous conditions attending the execution of Government contracts, which make it difficult to find the sureties required and which have caused the failure of such guarantors from the arbitrary interpretations

imposed by incompetent inspectors placed upon the works and whose orders are absolute, which conditions add largely to the cost of Government works and thus tend to limit the benefits and extent of the appropriations.

6. The policy of rejecting or suppressing thoroughly guaranteed proposals for the opening of rivers and harbors under bonds for the successful completion of the works and for payments to be made only as the channels are obtained, is believed to be another serious cause for the absence of greater depths which could be secured by the use of the energy stored in currents of the rivers or in the tides of the seas.

None of the above causes are physical, but they are incidental to legislation, and as soon as our legislators and others can see their way to adjust them so as to open the door to a general movement for work all along the line, just so soon will the facilities begin to be provided on a scale commensurate with the needs of a great and industrious nation.

TWO SIDES TO "CÖOPERATION."

The proposition to cöoperate with interests not now aggressively taking part in these improvements is an excellent and desirable one, but it has been sadly perverted. In former times, under the old régime, it was the Government that occasionally cöoperated with the States by contributing to some of the works undertaken under their charters and thus becoming a partner in the corporations thus organized, as in the case of the Chesapeake and Delaware Canal Company, in which the United States is still a shareholder; but in more recent days the tables are turned, and cöoperation appears to mean a contribution from the locality desiring improvements to the extent of large appropriations made to the Treasury of the United States to induce it to inaugurate the necessary improvements, and yet even this is not always effective in securing even a survey for deeper channels, although the entire expense thereof may be borne by the locality. This is the kind of cöoperation which places all the funds and all control in the hands of the centralized authority without producing the desired relief and is not such as would improve the situation physically.

It will be many years before the physical data and the various conditions affecting our economic resources can be collected and

thoroughly digested and formulated, by which time the growth of the population and its productivity will have again modified extensively the then existing conditions so that it would appear to be of great importance to frame some general legislation as a basis for the general development of navigable channels at the earliest moment and make provision for a permanent and radical policy of conducting our public civil works if this generation is to derive any benefit from the movement.

In the Preliminary Report as submitted, although signed by all the members, it appears that there were dissenting views as to how its findings should be rendered effective, and the appendix submitted by Senator Newlands, the earnest and successful advocate of the irrigation and reclamation projects, are so pertinent that they deserve the attention of all good citizens, interested in the welfare of the nation. What the Senator says in his supplementary report is this:

"I desire to emphasize my belief that it is of the highest importance that in dealing with subjects relating to the respective powers, rights and interests of the Nation, States, municipalities, corporations and individuals, large powers and a comparatively free hand should be given to an administrative body of experts in the full development of projects, lest the complexity of the transactions, the time necessary to secure Congressional approval, and the difference of view as to purpose or method, may result in indecision and delay, the worst enemies of effective development.

"An ample fund should be provided, to be reinforced from time to time either by the legislative appropriation or by bond issue, and the administrative board or commission should be given power, not only to investigate projects, but also, when determined to be feasible, to enter, with the approval of the President, upon their immediate execution; but the power should be limited so as to prevent such administrative body from entering into any contract unless there are sufficient moneys in the fund to meet the cost thereof.

"Unless some method of construction and development, insuring prompt decision and execution and continuous and consecutive work by a body of experts is adopted, I fear that the best of projects may be wrecked in the shoals and quicksands of legislation."

This fear has been confirmed by past experience, time and

again, and it would seem to meet the situation fully to adopt the policy of awarding contracts to any responsible parties who may volunteer to bid upon a guaranty of payments for results secured within reasonable time limts, in which case no risk is taken by the Government and there is an immediate return for the moneys expended. In the few instances where this policy has been tried, the results were eminently satisfactory, but the precedents were not followed by Congress because of the opposition of the "system."

MAKING AN ARTESIAN WELL PUMP ITSELF.

The field men of the United States Geological Survey, in their investigations of the ground-water resources of the Virginia Coastal Plain, have observed that the flows from any artesian wells in that region are utilized to drive hydraulic rams for the purpose of lifting the water to higher levels. Along the lower courses of the Potomac and Rappahannock and along the shores of the many inlets that run back from Chesapeake Bay above the James, there are hundreds of artesian wells that supply a perennial flow of beautiful clear water which is, as a rule, excellently adapted to all domestic uses and is largely utilized by the canning factories and other industrial establishments that abound in that part of the country. Though the pressure of the water from the wells is ample at the shore level, the head diminishes so quickly with increase in elevation that no flow can be obtained along the higher banks above the shore, where the water is most needed. The common method of obtaining it at these higher levels is to use the force developed by the artesian flow to operate hydraulic rams, which in turn raise the water to the heights desired along the bluffs above the rivers and inlets. Thus it may be said that the artesian wells pump themselves.

TOPOGRAPHIC WORK IN NEW YORK.

The United States Geological Survey announces the completion of plans for topographic work in New York, which is performed under cooperative agreement with the State Engineer and Surveyor.

Under these plans the mapping of the Cooperstown and Delhi quadrangles will be brought to completion, and secondary control will be carried over the Neversink, Monticello, Bath, and Stony Creek quadrangles. The work on the first four of these quadrangles has been assigned to C. E. Cooke, who is assisted by W. H. S. Morey, but assignments for the Bath and Stony Creek quadrangles have not yet been made.

The expense of the field work is shared equally by the State and Federal Survey.

Saving the Forests and Streams of the United States.*

By Dr. Thomas E. Will,

Secretary of the American Forestry Association.

We have thought of our natural resources as inexhaustible. Observation and experience are teaching us our mistake. Says a nameless writer in the *Commercial West*:

"The discoverers of America found themselves chin deep in a reservoir of rich natural resources. Your grandfather was in it up to his shoulders. Your father waded around waist deep in God's reserve of material mercy. You are standing in it knee deep. Your boy will find some of the rich original mud on his shoe soles, and your grand son will be raking over the dump for some of the old, abandoned scraps of the gone-by Golden Age. It will be but about five hundred years from the discovery of America to the final looting of her fat inheritance."

Among the resources thus destroyed, the forests are one of the most important. Former Judge Howland, President of the Association for the Protection of the Adirondacks, is authority for the statement, that on Sunday, March 25, 1903, a New York paper, circulating some 800,000 copies, consisted of eighty pages. "This single edition," he said, "required the product of 9,779 trees sixty feet high and ten inches in diameter at breast height, which, if planted forty feet apart, would represent a forest area of 351.8 acres."

In the United States were once four great forest areas, those respectively of New England, the Great Lake region, the Northwest and the South. Of these, the first two are largely gone, and the third and fourth are disappearing with bewildering speed.

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*A lecture before the Franklin Institute, Friday evening, November 1, 1907.

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Black walnut (Juglans nigra), Harlan County, Kentucky

The question of conserving what remains of the forests of the Northwest and the South and of renewing our denuded forest areas, is one of foremost importance to the people of the United States.

The hardwood question is, of itself, of vast import. American hardwoods once lay in four regions: Those of the Great Lakes, the Ohio Valley, the lower Mississippi and the Southern Appalachians. Of these, the first three are largely gone and the chief reliance of the American people for hardwood is now upon the Southern Appalachian area. This fact alone renders the Appalachian Mountain forest question national.

What would the loss of our hardwoods signify? Take an illustration. The business man spends the day before a desk of solid sand-stone; in the evening, he adjusts his toilet before a concrete dresser, joins his family around a cement dining table, enters next with them his library; hands his wife a sheet-iron rocking chair, stretches himself upon a chilled steel sofa and proceeds to spend the evening listening to his daughter discourse music, more or less sweet, from a cast-iron piano.

Many forces are cöoperating to destroy our forests. Windstorms and insect pests commit ravages. Unrestricted grazing, notably by sheep, destroys the young growth and prevents reproduction. Man and fire are the chief agencies of destruction. The attempt to cultivate forested mountain slopes leads to clearing, and to exhaustion of the soil, and leaves areas of desolation on the mountain sides. The old-fashioned boxing method of turpentining is wasteful. With modern methods, the lumbermen harvest our forests as Dakota farmers harvest great fields of wheat, but with this difference: the farmer plans for future crops; the lumberman plans but for one. With him, it is once and out.

Our normal consumption of wood is prodigious. We use annually enough lumber to floor the state of Delaware, enough shingles to shingle the District of Columbia, enough laths to load a railroad train extending from Boston to Ohio, enough tight cooperage stock to build a rick four feet wide, four feet high and reaching from New York City to Colorado; enough fire wood to make a wood pile a half mile wide, a half mile deep and a half mile high; enough railway ties to build a railway extending round the world and back across the Atlantic, and the amount of our annual wood bill exceeds a billion dollars.

But to the use we must add the waste. The figures are appalling. We leave more than half the crop in the woods as kindling for forest fires. The rapidity with which we have burned up our forests is inconceivable. The forest fires of 1871 destroyed more

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Caspar, Mendocino County, Cal. Yarding donkey and yarding crew. Turn about to be hauled out by bull donkey.

property than the Chicago fire, and the fires of 1881 were still more destructive. Outside our National Forests the besom of destruction still sweeps on.

Said Dr. B. E. Fernow: "It has been officially estimated that forest fires in the United States destroy annually about $50,000,000 of standing timber and burn over an area of at least 15,000,000 acres. In twenty-eight States, the area burned over in one year was pretty accurately estimated at about 7,789,734 acres, and the loss close to $24,000,000."

How long will our stock last at this rate? Nobody knows exactly. It is hoped that a timber census will be taken through the cöoperation of the Forest Service and the United States Census that the facts may be made available. We are certainly using up

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our wood three times as fast as we are producing it. Under present policies, two or three decades will surely see the finish of our forest heritage. Were this period twice as long, in the life of a nation it would be but the infinitesimal fraction of the diameter of a hair. Already the shadow of the timber famine is upon the land. What this may mean we may learn from China, whose forests were long since destroyed. A recent newspaper cartoon picturing the ruin of American cities and showing the transportation, by caravans of camels, of corn through the desert of Iowa to Chicago, is suggestive.

Says Mr. Gifford Pinchot, Forester of the United States Department of Agriculture:

"Under present policies of use and waste, the timber supply of the United States will last probably from twenty to thirty-three years.

"When the forests fail, the lumber business, now the fourth greatest industry in the country, will, of course, disappear. Suffering among all building industries will immediately follow. Mining will become greatly more expensive; then naturally the price of coal, iron, and all other minerals will rise; by this the railroads will be directly affected and the cost of transportation and water power for lighting, manufacturing and transportation will immediately increase. All goods made from products of the mines will increase in price, which will hamper, not only agriculture, but the cost of production generally. In fine, when the forests fail, every man, woman and child in the United States will feel the pinch. And through misuse the forests are failing rapidly."

More important, probably, than the wood question, is the water question. Consider this question with especial reference to the East and South.

Practically all the important rivers of the South, east of the Mississippi, whether flowing into the Atlantic, the Gulf, or the Ohio system, rise in the Southern Appalachian Mountains. Likewise, practically all the important rivers of New England rise in the White Mountains.

For agricultural purposes, these rivers are indispensable. For navigation, their possibilities are great. In manufacturing, furthermore, these possibilities are being realized.

Since 1812, New England has been a great manufacturing section. Since 1890, the South also has been striding toward the front as a manufacturing section. As the cotton-gin typified the old-time, agricultural, slave-holding South, so the cotton-mill typifies the new, industrial, manufacturing South.

Mills and factories to-day are coming to be driven less and less by steam, generated from coal, and more and more by water, either applied directly or employed in generating electricity, which itself drives the machinery. In either case this water comes from the rivers which rise in the mountains. Its value is absolutely dependent upon its equable flow. A stream which pours forth

floods at certain seasons, and runs dry in others, is worthless and worse for manufacturing purposes. One prime problem with the manufacturer is how to maintain an even flow of the stream the year round.

To this end forests on the slopes in which the streams rise are of incalculable importance. Falling upon a densely forested slope the force of the rain is broken, preventing erosion. The water falls gently upon the forest floor where, to the point of saturation, it is absorbed by the forest mulch or carpet of leaves, branches and decayed vegetable matter, and passed slowly into the porous earth. Here it enters the underground circulation and, through days and weeks, passes slowly downward, emerging, in time, from springs to feed the rivulets and rills which, in turn, supply the streams, water the fields, carry the commerce and drive the wheels of mills and factories.

But let this mountain slope be swept by ax and fire. Often the bare rocks alone remain. Nothing now intervenes to check erosion or to absorb the rainfall and pass it into the underground circulation. Instead, like the Gadarene swine, it rushes violently down the steep place, carrying before it silt, sand, boulders, débris, whatever may be movable, depositing this in the streams.

Note the two-fold phenomenon. The water enters the streams suddenly, rather than gradually, and finds the channels largely filled with foreign matter. Inevitably, there follows the overflow and the flood. In a single year (1901-02) in a single section of the South, floods destroyed eighteen million dollars' worth of property. The Ohio River floods of last Spring are still remembered.

Observe some of the consequences: Rich, alluvial soil is swept from fields where it is indispensable, into rivers and harbors, where it is an expensive nuisance. In two or three decades river bottom farms, once worth one hundred to two hundred dollars per acre, have been made worth less than ten dollars per acre, or destroyed. The good roads movement has been counterbalanced by a bad roads movement. Railroads, culverts, and railroad bridges are continuously washed out and swept away, impeding traffic and transportation and destroying necessary capital. At Spartanburg, S. C., the Pacolet flood of 1903 absolutely destroyed two great cotton mills of one company and seriously damaged or

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Looking up Ellijay creek towards the Cowee mountains, showing wash and abandoned slopes in right and old fields reset in young hard woods. Macon County, North Carolina.

Hillside erosion in abandoned fields. Catawba County, North Carolina.

destroyed many others in the neighborhood. This flood is traced largely to deforestation of slopes.

Says Mr. Charles A. Stone, of the firm of Stone & Webster, Electrical Engineers, Boston, Mass.:

"One of the most important features in the commercial development of a water-power enterprise is the uniformity of flow of the stream on which the development is undertaken. Where streams are subject to severe droughts or great floods, commercial development is practically impossible. Nature has provided for the uniformity of flow by covering the water-sheds at the headwaters of these streams with forests. * * * When these forests are cut off, conditions are entirely changed, and great freshets result."

Mr. Theophilus Parsons, a representative of the manufacturing interests of New England, says:

"New England is largely dependent upon her factories run by water-power. The flow of the rivers furnishing this power is growing yearly more uncertain. Both floods and droughts are more frequent. It is plenty or famine. This situation is due to the pernicious cutting of woods along the headwaters of the New England rivers.

"I have known the Connecticut for over thirty-six years. It drains an area of four thousand square miles. Until recently the wooded hills kept the flow of the river even. Now, in the spring, we have floods, while in the summer the water sometimes will not run our mills.

"This is a question in which every manufacturer on the eastern coast of the United States is interested."

In addressing the Committee on Agriculture of the House of Representatives on April 25, 1906, Mr. E. S. Watson, Agricultural Commissioner of South Carolina, testified that his State had something like $82,000,000 invested in cotton mills, which was constantly menaced by deforestation in mountains. He stated that some four and one-half million dollars were lost by the Pacolet flood. Sometimes as many as fourteen houses were washed away in a single night. Repeatedly he had seen whole sections of railway trestle which had been carried nearly 150 miles and landed in a fine plantation.

Such experiences are not new nor confined to the United States. China's great river, the Hoang-ho, is known as the "River of Sorrows." The frightful devastation and destruction

resulting from its repeated floods is well known. Scientific investigators trace these floods directly to the destruction of China's forests. To the same source they attribute, in a large measure, the awful famines which visit and revisit that unhappy land.

Mr. Bailey Willis, of the United States Geological Survey and the Carnegie Institute, said of China, in which country he had traveled:

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Railroad embankment on the Southern railway washed away in the freshet of May 21, 1902. When the embankment broke a large hole, more than 20 ft. deep, was washed out. This is where the pool is. An attempt was made to rebuild the road by a trestle, but it was found that the pool was too deep for a trestle to be built, so that a temporary road, shown on the left, was constructed around the pool. Greenlees, McDowell County, North Carolina.

"Large areas of Northern China have been rendered uninhabitable in consequence of deforestation, the hills being reduced to rocky skeletons and the valleys being filled with a coarse sand and gravel.

"Throughout Northern China the floods which have caused the Yellow River to receive the name 'The Grief of China,' are an immediate result of the deforested condition of the hills and the consequent rapid run-off of the spring and summer rains.

"The conditions resulting from deforestation cited in the two preceding statements add greatly to the severity of famines, since they very greatly reduce the productive area and occasion the failure of crops in flooded regions."

"The lingering tragedies," says the *Century Magazine*, editorially, "of those Mediterranean countries—Greece, Italy, France, Spain, and the African Coast—which permitted wholesale destruction of their forests, have been rehearsed for our warning,

> Till old Experience do attain
> To something of prophetic strain."

The stories of Dalmatia, the Karst, Asia-Minor, Syria and Palestine are startling. Says Mr. George P. Marsh, in "The Earth as Modified by Human Action:"

"We know that the clearing of the woods has in some cases produced, within two or three generations, effects as blasting as those generally ascribed to geological convulsions, and has laid waste the face of the earth more hopelessly than if it had been buried by a current of lava or a shower of volcanic sand." (P. 261.) "To the torrents (occasioned by deforestation) igneous rocks are as wheat to the mill stones * * * The fury of the waters and of the wind which accompanies them in the floods of the French-Alpine torrents is such, that large blocks of stone are hurled out of the bed of the stream to the height of twelve or thirteen feet." (P. 265.)

Landslides have followed deforestation. One, on September 4, 1618, buried to a depth of seventy feet, the town of Plurs, in the Valley of the Maira. Another on September 2, 1806, destroyed the town of Goldau, Switzerland, and four hundred and fifty people. Instances might be multiplied.

Following her revolution of 1789, France destroyed her forests at an unprecedented rate. Soon she began experiencing the effects already described; overflows, floods, devastation. Like us, ignoring causes and striking simply at effects, she began dredging out her streams and harbors. But in vain, for fresh deposits of silt and sand followed close on the heels of the dredgers. At last, ascending the streams, the engineers discovered the cause: the downward sweep of eroded matter from deforested mountain slopes. Then came the gradual and expensive application of the remedy; the purchase by Government of

mountain sides, the erection of barriers of wood or stone to hold back the earth flood, and then the gradual reforestation of the slopes from which the forests should never have been removed.

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Statesboro, Ga. Cutting box. Long leaf pine near Ocilla, Georgia.

Said the United States Senate in its report No. 2537, on April 11, 1906:

"France began a work of reforesting denuded mountains in 1860, to repair, so far as possible, the damage which had followed the clearing of the forests under private ownership. By

1900 she had spent over $15,000,000 and acquired over 400,000 acres of land in this work, while annual expenditures were still going on at a rate of over $600,000 a year, and it was estimated that in the completing of the work the further purchase of over 425,000 acres of land and the additional expenditure of over $20,000,000 would be required. Owing chiefly to the necessity of acquiring for protective purposes deforested land, almost one-fourth of the State-owned forest in France must be nonproductive for many years."

We are repeating the experience of France in expending millions to remove from stream-beds and harbors deposits which forests would have retained on our mountain sides. Has not the time come when, instead of dallying ineffectually and expensively with results, we should attack causes themselves?

Happily, we have already begun this work. On March 3, 1891, Congress authorized the President to proclaim National Forest Reserves on the public domain. In consequence, we now have a National Forest area equal to all the States of the Union east of Ohio and north of North Carolina. On this, the United States Government, through the Forest Service of the Department of Agriculture, is actually solving the problem of forests and streams; *i. e.*, it is applying the principles of forestry to the management of our nationally owned and administered forests.

Do the principles of forestry forbid cutting? By no means. They require cutting. The scientific forester regards a forest as a scientific and practical farmer regards a field, namely, as a continuous source of wealth. The forest, like the field, if rightly handled may be used in perpetuity. Trees fit to be cut are cut; those needful to be saved to perpetuate the forest conditions,—cover, floor and what not,—and to ensure reproduction, are carefully preserved. Furthermore, the brush resulting from cutting, instead of being left scattered over the ground as food for a forest conflagration, is piled and burned under careful supervision. Thus, while its product is used, the forest, as such, is saved.

The fire problem receives careful attention. By means of fire lines and trails the forest is laid out into areas of convenient size, that fires may be segregated. Daily, during the danger season, the forest rangers, from some eminence, inspect the areas entrusted to their care. The sight of a suspicious looking smoke means prompt investigation. Should fire be found, the force is at once

called out and, if necessary, supported by outsiders hired, and even drafted, for the occasion. The fire is attacked with a vigor worthy of a fire department.

And with what effect? The National Forests have been in charge of the Forest Service less than three years. In that brief time the forest fire problem on the National Forest area has been practically solved and fire damage reduced to a negligible quantity. This victory alone would have abundantly justified the en-

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Biltmore, North Carolina. Reproduction of Loblolly pine.

trance of the National Government upon the work of forest administration.

Planting, however, has also been begun. In Forest Service nurseries seedlings are produced to be transplanted to the sand-hill deserts of Nebraska and Kansas, or to denuded mountain slopes farther west.

That economy may be wisely practiced, the Forest Service is also testing timbers to ascertain their relative strength, and is furnishing the resultant data to wood users. To facilitate sub-

stitution of inferior wood for superior wood, so rapidly disappearing, timber treating is being developed. For example, on abandoned fields of the South there springs up a tree, abundant as the weed and almost as lightly esteemed, known as old-field, or loblolly pine. Experiment shows that, after a practical, simple, and but moderately expensive treatment with creosote, this hitherto despised but abundant wood becomes as valuable as untreated oak and hickory. The possibilities of such a discovery are vast.

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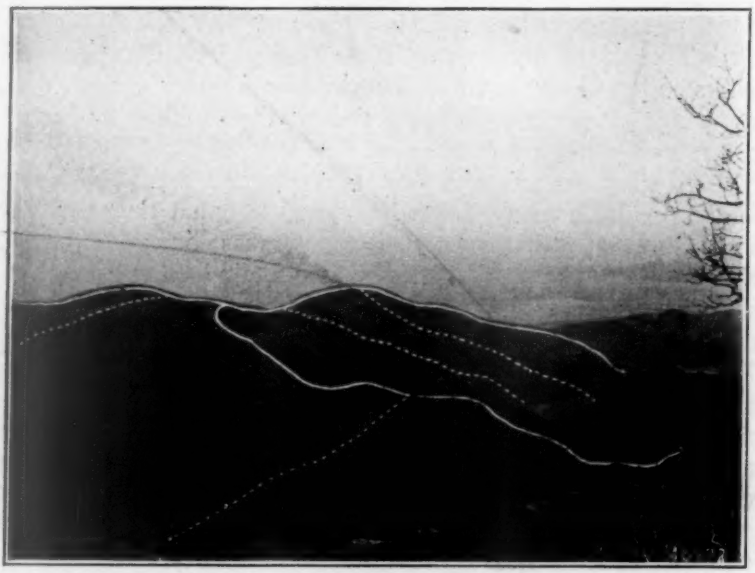


General view of chaparral covered foothills. To be used in panoramic view showing fire line San Bernardino National forest, near Skyland, California.

The Forest Service is engaged in numerous other lines of helpful work.

Especial attention is called to the fact that the chief contribution to the solution of the problem of forests and streams is being made by the National Government on the National Forests. These forests, however, are all in the West. Practically all of them are west of the hundredth meridian. The reason is not that National Forests are needed in the far West more than elsewhere; it is, instead, that the law of 1891 authorized the establishment of such forests by presidential proclamation and on the public do-

main. Comparatively little public domain is found elsewhere. The bulk of the population and business of the United States however lies east of the National Forests.

Such forests are imperatively needed elsewhere, notably in the Southern Appalachian and White Mountains. Here, however, they can be secured only by Congressional action. The Appalachian-White Mountain Bill, providing for the establishment of these forests, has twice passed the Senate, was twice recommended for passage by the House Committee on Agriculture, was twice recommended by President McKinley through special messages, and once, in like manner, by President Roosevelt. Thus far, however, the House of Representatives, though understood to be favorable, has never found opportunity to vote on the bill. It is earnestly hoped that this opportunity will come to that body at the present session.

In 1899, Congress was first memorialized to establish the Southern Appalachian National Forests. At that time the National Government had opportunity to purchase one and one-half million acres of cheap, forest-covered mountain land at a price averaging $2.50 per acre, including the timber. To-day, the same land could not be procured for an average of $10 per acre. Had Congress, in 1899, acted promptly upon the memorial then presented to it, it would have gained from twelve million to fifteen million dollars in the mere price of this land, to say nothing of the vast economies which would have been effected through the prevention of wasteful cutting, fires, floods, and other evils consequent upon forest destruction. Like the Sibylline Books, the price of this land must continue to rise, and every day's delay must add both to the waste and to the expense which must be incurred by the Nation when the inevitable purchase comes.

Important as is the economic side of this question, there is another side equally or more important. It is that of the public health. Our people work too much and rest too little. Too largely are they confined in great cities, subject to an intense industrial pressure, cut off from access to the fields and woods, and deprived of the culture which comes with fellowship with Nature. The tendency toward exclusive city life should be counteracted. Increasing opportunity should be afforded our people, old and young, to visit the forests and streams, to rest their wearied bodies and recuperate their shattered nerves and fit themselves for larger,

completer living. To this end, our mountain forests are essential. Said the United States Senate, in its report above quoted:

"The White Mountains and the Southern Appalachians are alike in being natural recreation grounds for a very large part of our population. Over 60,000,000 of the people of the United States are within twenty-four hours of the Southern Appalachians, and the White Mountains have long held a foremost place as a summer resort, especially for the Northern and Middle Atlantic States. Both of these regions should be guarded and handed down to the generations which follow. They are great natural blessings with which we have been endowed and which we must protect."

This doctrine is eminently sane and wholesome. But to live up to it, we must stop the destruction now in progress in the forests of our eastern mountains; and in no way can this be done but by such action of the National Government as is contemplated in the Appalachian-White Mountain Bill.

THE STEEL RAILROAD TIE.

In view of the great interest taken in the action of the Pennsylvania Railroad Company in ordering the steel ties in its tracks at Mineral Point, Pa., to be replaced with wooden ones, the following communication from the chief engineer, A. C. Shand, to the *Railroad Gazette*, is highly important;

"Relative to the report made of the recent accident to train No. 29 on the Pennsylvania Railroad in the vicinity of Mineral Point, full copy of which appeared in your issue of Friday, March 1, 1907, I think you have written a very fair and creditable editorial on the subject, including not only the Pennsylvania Railroad accident but the accident on the New York Central, which occurred recently. The general impression seems to prevail, however, in nearly all the papers which have been brought to my observation that the steel cross ties for railroad track purposes are a failure.

"I would be greatly obliged if you would call the attention of your readers to the fact that, after most careful observation and study of the subject, I am more than ever impressed with the necessity in the near future of a substitute for wooden cross ties, and so far no material has been offered as a substitute that will meet the requirements except metal. I think, however, that all ties tested are a little lighter than they should be, and am firmly of the opinion that none of the fastenings for holding the rail in position to the tie is adequate to the requirements. This was emphasized in the accident we had, above referred to. When any suitable fastening shall have been designed, and there is no doubt in my mind that it will be in the near future, either by the Carnegie Steel Company or by some one else, I have not the slightest doubt that the experiments in con-

nection with the steel ties will go forward, not only on this system but on other leading railroads.

"On the Pennsylvania Railroad alone we are using about 4,000,000 cross ties a year, and with the increased price of cross ties in the last five years, and the difficulty in purchasing even at the increased price, it is obvious that some substitute must be secured before long. The quality of the timber also has depreciated enormously in the last five years, so that it becomes imperative that we should either purchase the best cross ties that the market affords and creosote these ties and use heavy tie plates, or secure a steel cross tie or one of some other composition which will answer the requirements. This company a number of years ago laid four sections of track with the steel tie as used at the time by some of the English railroads. These were of the inverted trough design, but did not give satisfactory results.

"What I am afraid of is that the general public, and the engineering profession in particular, will dismiss the subject of steel ties as a failure, when in reality they must come sooner or later, and the more intelligent thought given to this matter the sooner a suitable tie will be furnished which will be satisfactory in every particular."

This utterance from one who occupies so high an official position, and therefore fully appreciates the importance attached to whatever he may say, should set at rest the popular belief that the Pennsylvania Railroad Company has placed the seal of its condemnation on the steel tie. The manufacture of steel ties is one which has in it the promise of great possibilities, and the entire steel trade is therefore deeply interested in anything which may develop regarding it. There is no doubt that the ingenuity of American manufacturers will be successfully applied to the production of a steel tie which will fully meet the requirements of railroad engineers.

FIRST INTERNATIONAL CONGRESS FOR THE ADAPTATION OF ROADS TO MODERN TRAFFIC, 1908.

Preliminary announcement is made by order of the Minister of Public Works of France of the meeting of the First International Congress for the Adaptation of Roads to Modern Traffic, which will be held in Paris late in the year 1908.

The object of the Congress is to ascertain what has been accomplished in road engineering in various parts of the world.

The extensive use of automobiles in France has brought out the fact that the macadam road is no longer suitable for highways. Both from a hygienic and engineering point of view it is no longer desirable, and the French Government will endeavor to ascertain whether roads of the future shall be made of asphalt or some other material, and whether tarring, which has been tried with a degree of success, will solve the problem of the disposal of dust and mud.

In connection with the Congress there will be held the First International Exhibition of Machinery used for the construction, maintenance and cleaning of streets and roads.

(Stated meeting held Wednesday, February 19, 1908.)

A New Radiation Pyrometer.

By Charles Burton Thwing, Ph.D.

The instrument to be described is the outcome of an attempt to produce an accurate means of measuring the higher temperatures used in ceramic and metallurgical operations which should be at once simple, portable and direct reading, so as to make possible the quick and accurate determination of high temperatures by ordinary workmen.

The principle employed is the measurement of the total energy of radiation by means of the current generated in a sensitive thermo-couple by the radiations concentrated upon it. The principle has already been employed by Féry in his "Pyrometric Telescope."

The novel features of the new pyrometer relate both to the means employed for concentrating the radiations and to the design of the galvanometer used for measuring the current generated in the thermo-couple.

The Stefan-Boltzmann Radiation Law may be stated as follows: The energy radiated by a black body is proportional to the fourth power of the absolute temperature, or

$$E = K (T_c^4 - T^4).$$

where E is the total energy radiated by a body of absolute temperature T° to a body of absolute temperature T_c°, and K is a constant depending on the units used.

The validity of this law is unquestioned. The conditions furnished by a black body are closely realized by such substances as clay and porcelain and by iron and other metals in the solid state as well as by any body whatever which is contained in an enclosure

having a small opening only. The departure of molten iron and copper from the conditions of a "black body" will be referred to toward the close of this paper.

It is highly desirable for rapid work that the Receiving Tube of the pyrometer should be so designed as to be independent of the distance of the hot body from the tube, so as to avoid the loss of time required for focusing and to eliminate the possible error due to inaccurate focusing. This end has been attained in the pyrometer under consideration by the use of a conical mirror for concentrating the radiations. It is evident from a consideration of Figure 1 that, since the containing tube is dead black, no radiations reach the conical mirror from any part of the observed surface outside the solid angle A OA′ and all radiations from the surface falling within this angle are transmitted by multiple reflection to the thermo- couple at the small end of the cone. If, for example,

Fig. 1. Diagram showing why the readings of Thwing's radiation pyrometer are independent of distance from the object.

the energy, E, received from a surface of area S at a distance $\overline{OA}$ be compared with the energy, E′, received from the larger portion of the same surface S′ subtended when the distance is $\overline{OB} = 2\,\overline{OA}$ it will be seen that,

$$\frac{E}{E'} = \frac{S/\overline{OA}}{4S/4\overline{OA}} \text{ or, } E = E'$$

since the area increases with the square of the distance and the intensity varies inversely with the square of the distance.

In practice the indications are found to be thus independent of distance, the one condition being of course fulfilled, that the surface is of sufficient area to fill the solid angle OBB′.

In the portable form of pyrometer the Receiving Tube is about 70 cm. long and 25 cm. in diameter. In the stationary type the tube is made shorter and is shielded from the disturbing effect of local temperature variations by a jacket containing water or oil.

It is found desirable in most cases to point at the inner wall of a tube of fireclay or iron which projects into the furnace far enough to take the temperature of the surrounding gases without

permitting the ingress of cold air to the furnace. Suitable leads conduct the current generated by the radiations from the thermo-couple to the indicating or recording galvanometer, as shown in Fig. 2.

It is important that the galvanometer used with the portable receiving tube should be of a form which does not require leveling and at the same time sufficiently sensitive to respond to the small

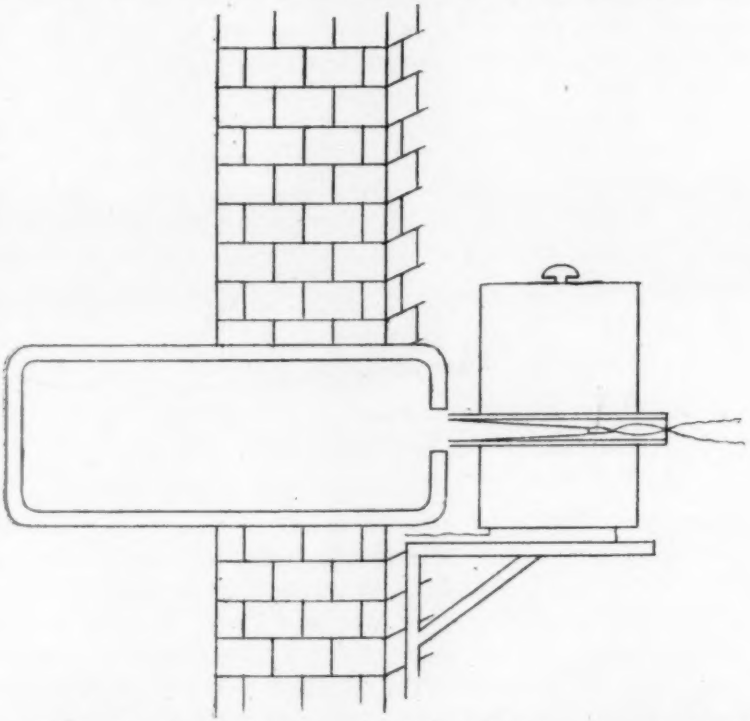


Fig. 2. Showing water jacketed receiving tube in position for continuous record.

current generated in the thermo-couple by a difference of temperature never exceeding 150 degrees Centigrade. As ordinarily constructed for thermo-electric measurements the D'Arsonval galvanometer must have included in circuit with the moving coil, to diminish the error due to changes in the temperature of the air, a large dead resistance of negligible temperature coefficient. This added resistance greatly reduces the sensitiveness of the instrument.

The device which I have adopted for overcoming this error effects a complete compensation without in the least diminishing the sensibility and thus permits the use of a pivoted coil which does not necessitate leveling the instrument. Incidentally the new design employs very light magnets so that the complete instrument weighs but three pounds.

The principle made use of in effecting the compensation is as follows: The deflection of a coil carrying a current in a field of magnetic force is proportional to the current traversing the coil and to the magnetic flux through the air gap of the magnet. The magnetic flux is, for a small air gap, inversely proportional to the length of the air gap, since the flux is proportional to the reciprocal of the reluctance and the latter is, owing to the low reluctance of steel, almost all in the air gap.

The method of applying the principle is illustrated in Fig. 3, which is a diagram of the electric and magnetic circuits of the galvanometer. The coil rotates about one of its ends in a uniform field between two plane pole pieces. The two magnets that are connected in parallel by these pole pieces differ from those ordinarily employed in being very thin and therefore quite flexible. These magnets are pressed together somewhat by the long end of a strong lever, the short end of which rests upon a post which is part of the aluminum case. Near the bearing of the lever on the post and at the proper distance from it the lever is pierced by a light rod of invar metal, which serves to apply pressure to the magnets. If the temperature of the air rises the aluminum post will expand much more than the invar rod, thus forcing the long end of the lever downward and diminishing the gap between the poles of the magnet by an amount which may be made accurately to compensate for the corresponding increase of electrical resistance in the coil. In practice the device is found to accomplish its purpose with remarkable accuracy, and thus to solve one of the

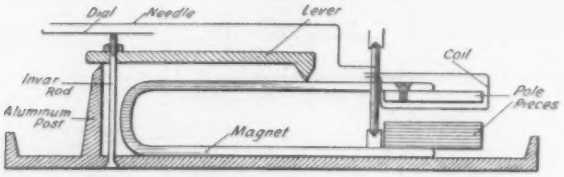


Fig. 3. Device for compensating for variation of resistance with temperature.

most serious difficulties in the way of making an accurate and at the same time sensitive portable galvanometer.

The portable galvanometer with receiving tube attached is shown in Fig. 4. An automatic arrestment for the coil is actuated by lifting the instrument by its handle. Fig. 5 shows a typical scale plate.

Fig. 4. Portable pyrometer complete.

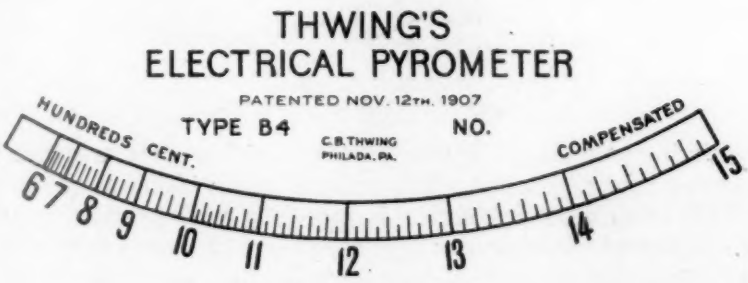


Fig. 5. A typical scale.

The pyrometer responds instantly to temperature changes, attaining a state of equilibrium in three or four seconds after pointing at the hot surface and returning as quickly to null reading when the radiations are cut off.

The possible range of temperature is unlimited in either direction. It has been adapted to the measurement of the temperature of mangle rolls in a laundry where the maximum temperature is 200° Centigrade. A contact couple was here objectionable because of its liability to collect and discharge dirt. Another example of the same sort is the measurement of boiler wall temperatures where contact of any sort of thermometer changes the magnitude of the quantity to be measured.

Fig. 6 shows a wall type galvanometer, and Fig. 7 a recorder. The record is made by pressing the period type, carried at the end of the pointer, upon the paper each alternate second. In the in-

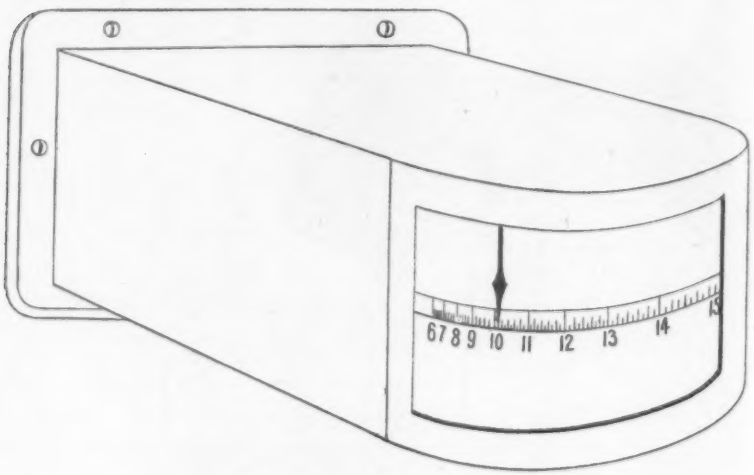


Fig. 6. Wall pattern galvanometer.

tervening seconds the needle returns to null position where it is pressed upon an ink pad. The entire record is visible at all times.

The Radiation Pyrometer is especially well adapted to the measurement of temperatures in open hearth furnaces and it was, of course, desired to supplement such measurements with determinations of the temperature of the molten metal at various stages. Numerous attempts made by the writer and others to measure the temperature of molten iron with the Féry radiation pyrometer led to results which were obviously much too low. The pyrometers employed were, in some cases, furnished for the express purpose of measuring temperature of molten iron, yet the reading obtained

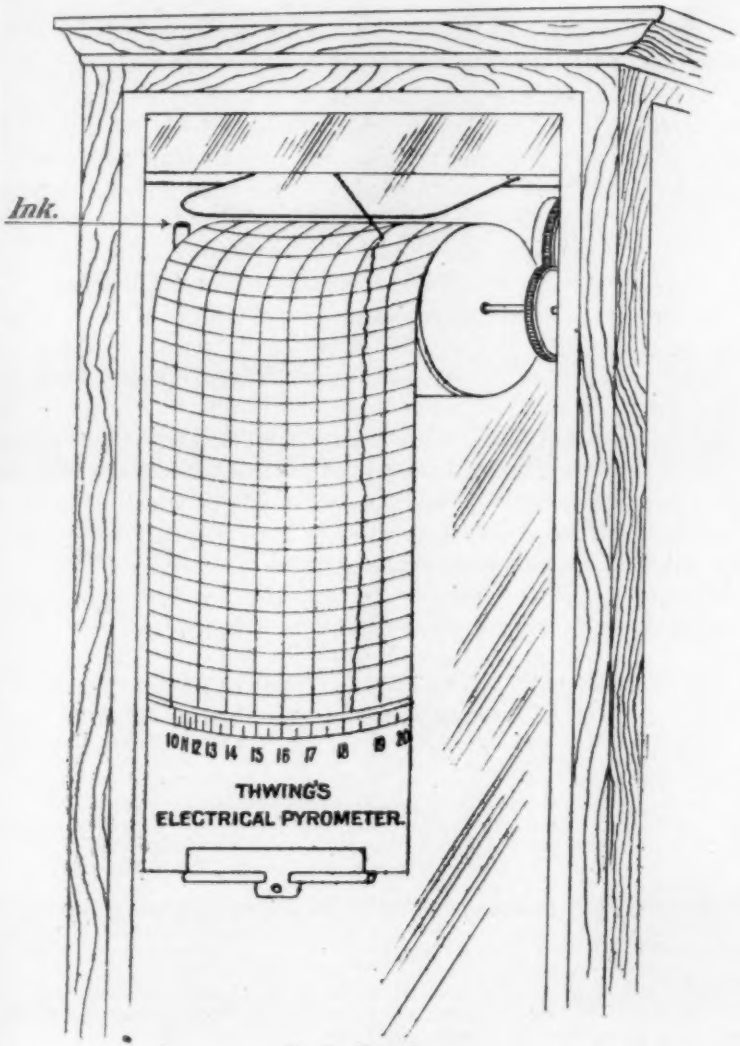


Fig. 7. Recorder.

by pointing the telescope at the flowing iron was considerably less than that obtained from the same iron when solidifying in the ladle.

A series of experiments tried with my pyrometer led to the conclusion that the emissivity of molten iron is much less than that of a black body and as no data were known a series of experiments were undertaken to determine, at least roughly, the value of the constant of radiation for molten iron and copper, since the importance of a knowledge of the temperature of these metals in various industrial operations is coming to be recognized as of considerable importance and the principle of total radiation furnishes a convenient method of making such measurements.

The results of these experiments were embodied in a paper read by the writer before the American Physical Society on October 19, 1907, and published in the Physical Review for February, 1908.

By direct comparison with a Le Chatelier pyrometer it was found that the intensity of the radiation from molten iron is but .28 as much and from molten copper but .14 as much as from a black body at the same temperature. It is necessary, therefore, to employ for such measurements an instrument calibrated for that purpose or else to multiply the readings obtained with a regular instrument by the proper constant.

SHRINKAGE OF WOOD WHEN DRIED.

Forest Service, Washington, D.C. Trade Bulletin No. 17.

Interesting experiments on the shrinkage of wood due to the loss of moisture have recently been completed by the Forest Service at its timber testing station, at Yale University. These experiments show that green wood does not shrink at all in drying until the amount of moisture in it has been reduced to about one-third of the dry weight of the wood. From this point on to the absolutely dry condition, the shrinkage in the area of cross-section of the wood is directly proportional to the amount of moisture removed.

The shrinkage of wood in a direction parallel to the grain is very small; so small in comparison with the shrinkage at right angles to the grain, that in computing the total shrinkage in volume, the longitudinal shrinkage may be neglected entirely.

The volumetric shrinkage varies with the different woods, being about 26 per cent. of the dry volume for the species of eucalyptus known as blue gum, and only about 7 per cent. for red cedar. For hickory, the shrinkage is about 20 per cent. of the dry volume, and for long-leaf pine about 15 per cent.

In the usual air dry condition, from 12 to 15 per cent. of moisture still remain in the wood, so that the shrinkage from the green condition to the air dry condition is only a trifle over half of that from the green to the absolutely dry state.—Forest Service, Forest Bulletin, No. 27.

Mining and Metallurgical Section.

(Stated meeting held Thursday, February 13, 1908.)

Practical Experiments in Steel.*

By Chas. L. Huston.

These experiments were undertaken in order to secure for practical purposes a more accurate knowledge of the interior character and structure of the material we are constantly dealing with in the manufacture of what is technically known as boiler plate steel, and used in the construction of boilers, bridges, ships, etc., where the safety of the travelling public is of vital consideration; where I think no one will dispute the statement that we ought to know all that we can learn about the characteristics of the material which enters into this and the safety of the ultimate structure made from it.

Much progress has been made since the first attempt to examine into and specify the character of material to be used in steam boilers, bridges, etc., but through it all I think the records will show the constant effort on the one hand to secure a material of higher tensile strength for carrying higher pressure or heavier loads with, on the other hand, continual vigilance on the part of those upon whom the responsibility of the public safety rests, to require evidences of ductility in the material to avoid the danger point which is approached when the increased tensile strength called for reaches the stage where brittleness results.

My late lamented father, Dr. Charles Huston, took a great interest in the earlier history of these questions and trained up his sons who succeeded him in the manufacture of boiler plate, with a

*For the use of the illustrations accompanying this paper the *Journal* is indebted to the *Proceedings of the American Society for Testing Materials.*

strong sense of their responsibility for the elements of safety in the material manufactured and put upon the market.

In the old days of iron, a sample selected from one part of the plate made in the usual manner was as a rule fairly representative of the quality of the material through the remainder of the same plate, the principal element of uncertainty being the question of incomplete welding.

In the early days of the use of steel it was assumed and generally believed that because the metal was all melted together and poured into large ingots to be rolled or otherwise worked into shape, the plates or shapes resulting would be almost, or absolutely, solid and homogeneous in character, but experience has shown that this early conception has not been entirely borne out, and men have found that the material is not absolutely solid, nor entirely uniform in character throughout the mass.

This lack of uniformity has become more noticeable as larger masses have been used, so that a careful investigation into the distribution and degree of this inequality seemed important.

It has been thought by many that the hardening elements were gathered toward the top of the ingot mass by floatation, and that if a good portion of discard was cut from this top end the remainder of the material would be comparatively uniform.

Others have discovered a tendency in hard or medium steels to segregate the hardening elements toward the center or axis of the mass and have concluded, as I also did at first, that this applied to soft steels as well, and that the resultant of this in combination with the floatation tendency was to form a trumpet-shaped hard portion somewhat similar in shape to the inverted "Christmas Tree" observed in a block of manufactured "can" ice.

With this in mind and a desire to examine into the general soundness and structure of some of our standard boiler steel ingots, I had several of them bi-sected vertically, and photographed, with drillings taken from the cut face, and analyses made from representative locations and properly grouped in a chart.

Several of these half ingots resulting from this bi-secting process I had rolled down into plates; also duplicates of the other bi-sected ingots rolled down into plates and cut up to get samples for physical testing purposes with the results appropriately charted, together with further analyses from the corresponding tests; I also show several additional charts to indicate the character and

Photo. 1

Photo. 2

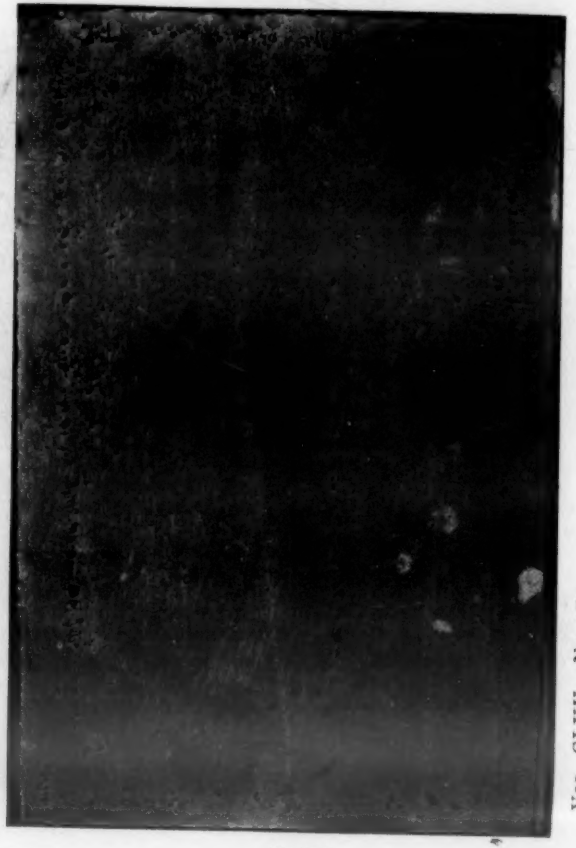


Photo. 3

degree of segregation in ingots of widely differing weights and shapes.

This much for general description and introduction.

Returning to the description of the charts and taking them up by number they may be described as follows:

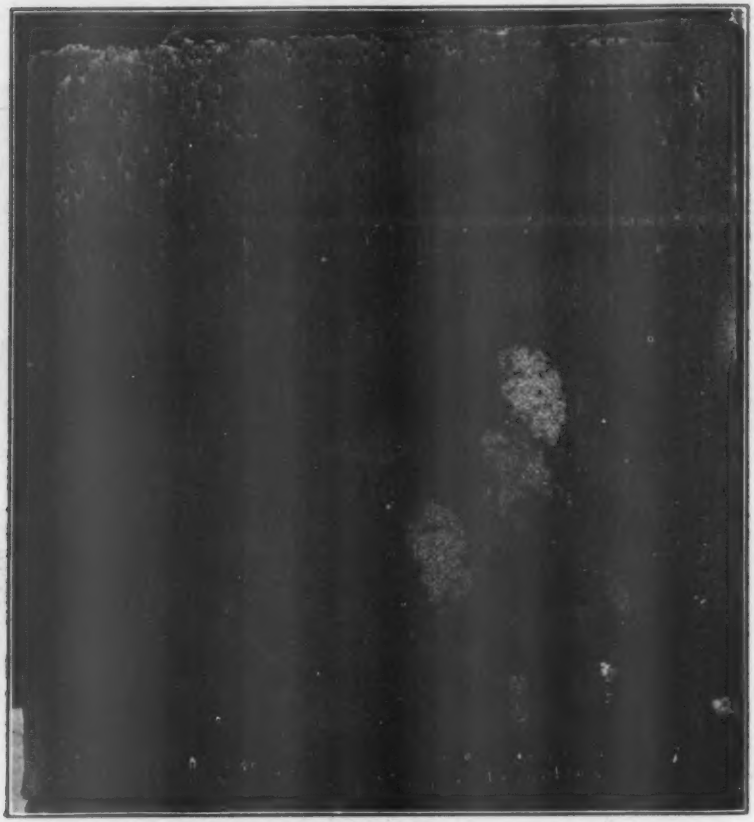


Photo. 4

Ingots as shown in photos Nos. 1, 2, 3, and 4 were all "bottom" poured at the same time in one group so as to see what, if any difference resulted from difference in shape and weight of ingot mass.

No. 1, 9″ x 12″ section; No. 2, 16″ x 18″; No. 3, 12″ x 26″,

and No. 4, 8″ x 38″, all about 36″ high, and showing carbon by ladle test .18.

Test charts Nos. 2, 3 and 4 were made from tests of plates rolled from exact duplicates of ingots No. 2, 3, and 4, poured in the same group.

These plates were all rolled about 31 feet long, 76″ wide and 5/16″ thick. Ingot No. 1 weighed about 900 pounds, while Nos. 2, 3, and 4 weighed about 2850 pounds each, the cross section, while varying decidedly in proportion, figuring up about the same area, and hence resulting in the same weight ingot.

Photo No. 5 was from the sample earlier described (size of ingot, 22″ x 15″, weight, 3775 pounds) as first bisected; section photographed and then the half ingot rolled into a plate for physical and chemical test as shown in test chart No. 5 (ladle test carbon .23, plate ⅜″ thick.)

Test chart No. 6, is from a larger size of ingot (not cut for photograph) and rather higher carbon, being of quality and carbon suitable for what is known as "Marine Steel," used for steamboat boilers, and subject to specifications of United States Board of Supervising Inspectors of Steam Vessels; this ingot was 20″ thick by 48″ wide, and weighed about 11,000 pounds; the plate was rolled to 29/32″ thick.

Test chart No. 7, (ingot not cut for photograph) was rolled from a large ingot 30″ thick by 34″ wide, weighing about 18,000 pounds, first rolled down and cut into eight slabs 29″ wide by 3½″ thick, then slabs reheated and rolled into plates ⅜″ thick all of one size for physical and chemical test, the location of the slabs as they were cut being carefully noted and traced so as to properly group the tests of the plates in the chart. Ladle test carbon 0.19.

No. 8, photograph shows an ingot cut in a rather different manner, having a quarter section cut out in order to observe the structure of the material in both ways of the section, after photographing.

The other quarter section was cut away and samples taken for chemical analysis, and the remaining bi-sected ingot rolled into a plate for physical test, as shown in test chart No. 8.

Test Chart No. 9, shows carbon determinations from drillings in the ends of the large slabs cut from an ingot of 30″ x 50″ size, weighing 30,600 pounds, the slabs being 50″ wide by 15″ thick. Ladle test carbon 0.23, the drillings being taken from the ends of

TEST NO.2

TOP

T.S. 56730 C. .13	67420 .25	67050 .27	66980 .25	56440 .13	T.S. C.
T.S. 55490 C. .13	64980 .22	65100 .23	64820 .23	56140 .13	T.S. C.
T.S. 57000 C. .14	64410 .23	64140 .22	64770 .21	56230 .14	T.S. C.
T.S. 55400 C. .13	63530 .21	62160 .20	62820 .21	56770 .14	T.S. C.
T.S. 56130 C .13	57720 .13	58400 .16	58140 .16	56900 .14	T.S C

BOTTOM

TEST NO.3

TOP

T.S. 55770 C .14	63100 .22	65090 .22	64540 .22	56200 .14	T.S. C
T.S. 55720 C .13	63030 .21	65200 .21	65160 .22	55070 .13	T.S C
T.S. 55530 C .13	62180 .22	62250 .22	61810 .21	55390 .13	T.S C
T.S. 55800 C .13	60440 .20	60870 .20	60830 .20	55420 .13	T.S C
T.S. 54190 C .13	58660 .17	58430 .18	58630 .18	55130 .13	T.S C

BOTTOM

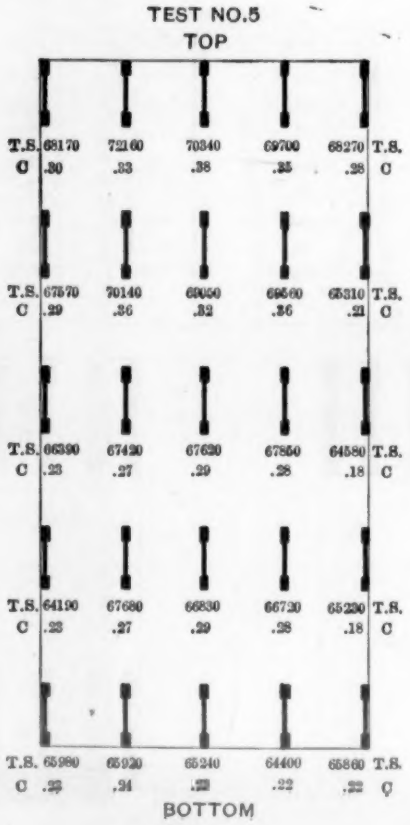
TEST NO.4

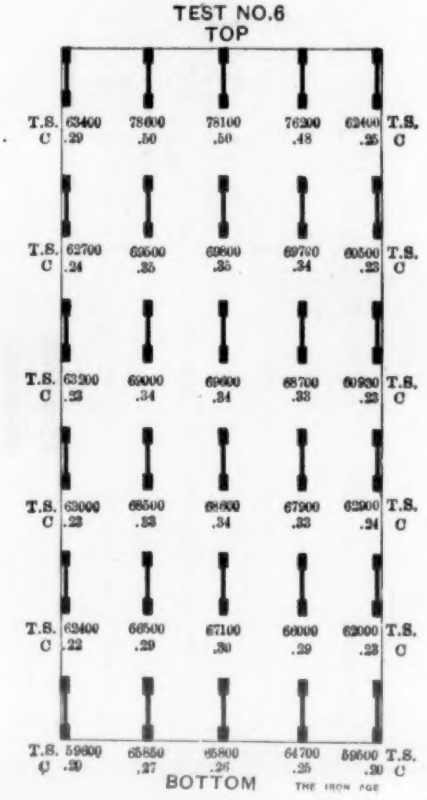
TOP

T.S. 60300 C .20	64120 .24	64900 23.	63250 .22	61510 .21	T.S. C
T.S. 57860 C .15	62820 .23	65410 22.	61960 .22	58340 .20	T.S. C
T.S. 58670 C .19	62460 .22	63060 .22	61210 .21	56180 .19	T.S. C
T.S. 56520 C .16	60250 .21	61420 .22	59900 .20	56130 .14	T.S C
T.S. 55180 C .14	57590 .17	59210 .18	56160 .18	55740 .14	T.S. C

BOTTOM

Photo. 5

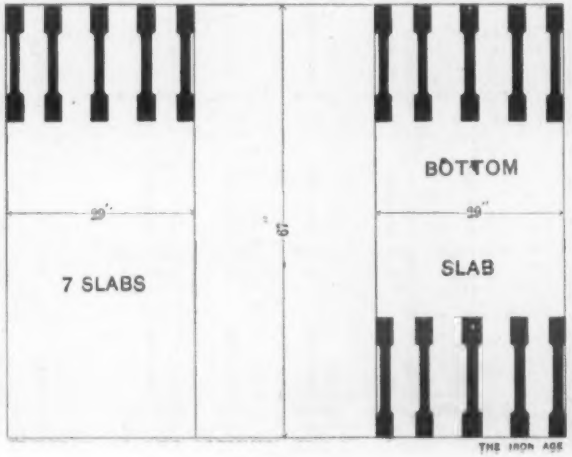

TEST NO.5
TOP
T.S. 68170 72160 70340 69700 68270 T.S.
C .30 .33 .38 .35 .28 C
T.S. 67570 70140 69050 66560 65310 T.S.
C .29 .36 .32 .26 .21 C
T.S. 66390 67420 67620 67850 64580 T.S.
C .23 .27 .29 .28 .18 C
T.S. 64190 67680 66830 66720 65230 T.S.
C .23 .27 .29 .28 .18 C
T.S. 65980 65920 65240 64400 65860 T.S.
C .33 .34 .23 .22 .22 C
BOTTOM


TEST NO.6
TOP
T.S. 63400 78600 78100 76200 62400 T.S.
C .29 .50 .50 .48 .25 C
T.S. 62700 69500 69800 69700 60500 T.S.
C .24 .35 .35 .34 .23 C
T.S. 63200 69000 69000 68700 60900 T.S.
C .23 .34 .34 .33 .23 C
T.S. 63000 68500 68600 67900 62900 T.S.
C .23 .33 .34 .33 .24 C
T.S. 62400 66500 67100 66000 62000 T.S.
C .22 .29 .30 .29 .23 C
T.S. 59600 65850 65800 64700 59500 T.S.
C .20 .27 .26 .25 .20 C
BOTTOM
THE IRON AGE

TEST NO.7

TOP	T.S. 61440	58460	58940	58260	57580	58080	59240	60060	59760	BOTTOM
	.17 C	.15 C	.15 C	.16 C	.16 C	.16 C	.15 C	.16 C	.16 C	
	71100	66940	66100	65500	65300	63400	61900	60840	60700	
	.27	.24	.23	.21	.19	.19	.19	.18	.15	
	77250	68200	65940	66300	65100	63400	62100	60320	58850	
	.38	.24	.22	.23	.21	.21	.17	.17	.15	
	73900	68020	65900	65860	64940	68300	61740	61000	59340	
	.35	.20	.22	.23	.22	.20	.15	.17	.16	
	59700	58800	58240	59100	57800	58380	59300	59540	59540	T.S.
	.13 C	.15 C	.16 C	.16 C	.15 C	.15 C	.15 C	.16 C	.16 C	

THE IRON AGE



THE IRON AGE

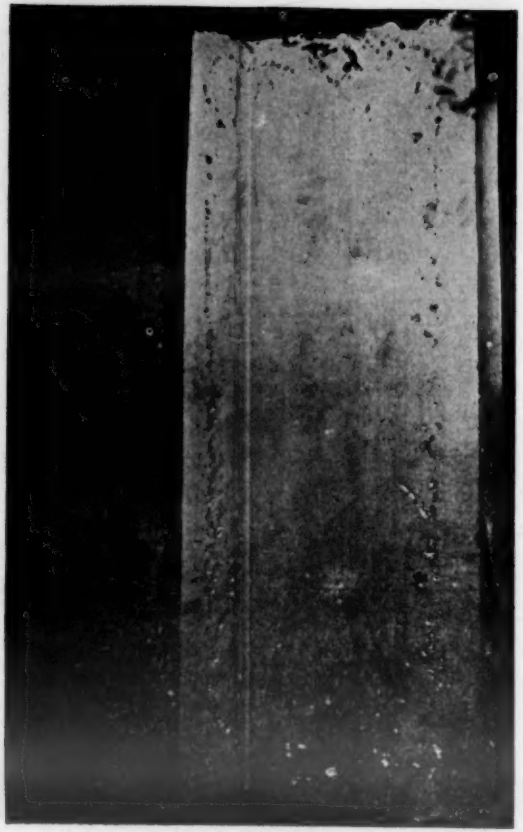
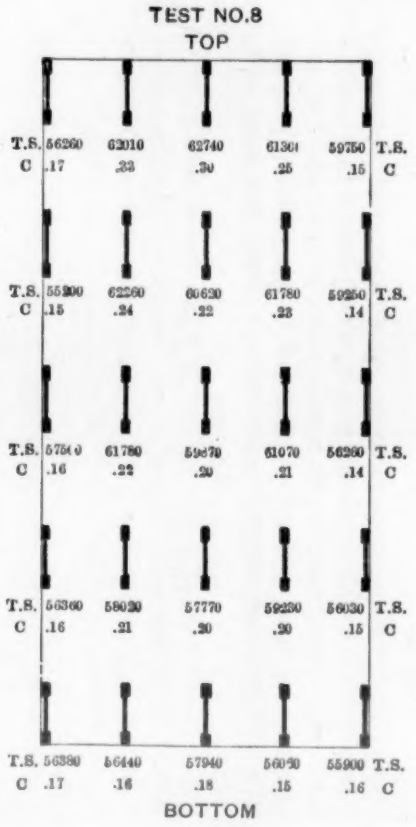
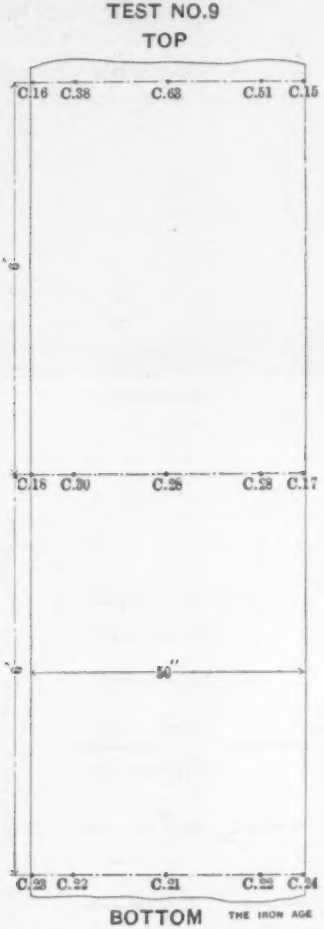


Photo. 8


TEST NO.8
TOP
T.S. 56260 62010 62740 61300 59750 T.S.
C .17 .23 .30 .25 .15 C
T.S. 55200 62260 60620 61780 59250 T.S.
C .15 .24 .22 .23 .14 C
T.S. 57580 61780 59870 61070 56260 T.S.
C .16 .22 .20 .21 .14 C
T.S. 56360 58020 57770 59230 56030 T.S.
C .16 .21 .20 .20 .15 C
T.S. 56380 56440 57940 56020 55900 T.S.
C .17 .16 .18 .15 .16 C
BOTTOM

the slabs as cut, so as to represent the central plane of the ingot metal.

These last two charts, Nos. 8 and 9, consequently show the carbon determinations for the central plane of the ingot, while all



the preceding ones show the carbon results from drillings taken entirely through the rolled plate, and hence correspond with the whole thickness of metal which each physical test piece represents, the drillings in each case being located to correspond as nearly as possible with the location of its corresponding sample for physical test.

When the physical and chemical test represent the same metal it will be noted that there is a close correspondence between the results, but when the carbon test represents only the central plane of the ingot as in charts Nos. 8, 9, and 10, the variation in carbon is greater proportionately than the variation in physical properties.

Chart No. 10 is a record of carbons taken across the face of the ingot shown in plate No. 3 and represented by chart No. 3, and made to ascertain where the greatest segregation lay in the line across the transverse axis of the ingot.

It will be seen from these charts showing a wide range of sizes and shapes of ingots that the general character of the segregation is the same.

As the steel cools in the mold a steadily thickening wall of solidified metal forms against the sides of the mold (which is usually of cast-iron) and numbers of gas bubbles form and rise to the surface in the liquid portion, causing a rising current of metal adjacent to the solidified wall with return downward current in the center.

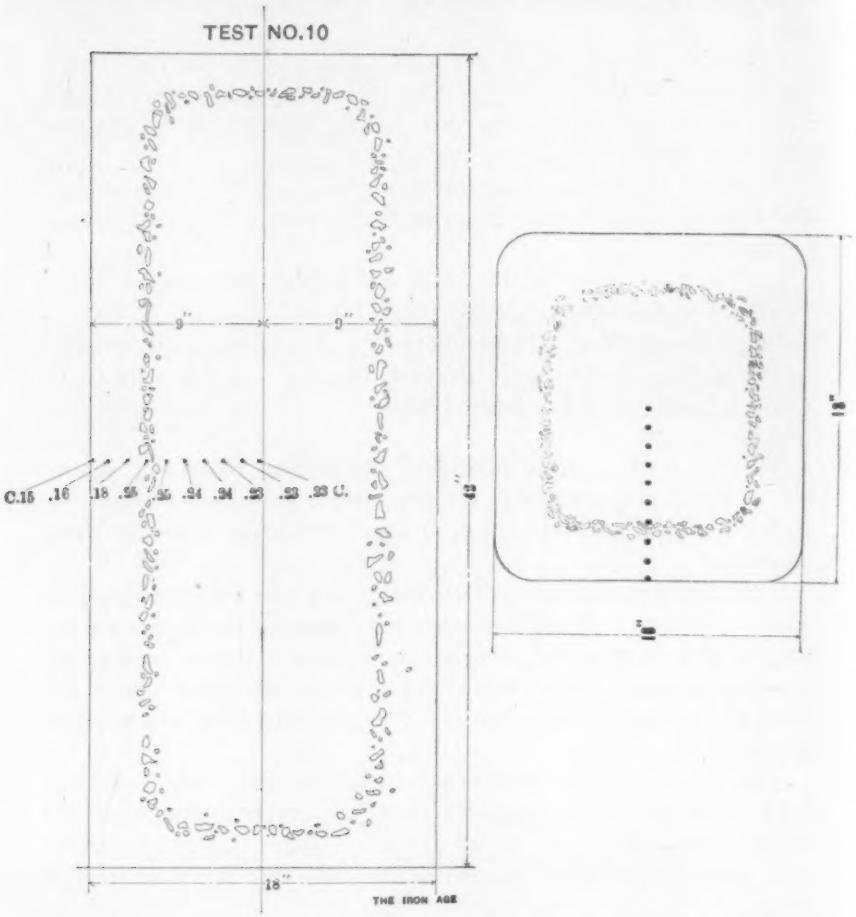
This causes thorough mixing of the portion remaining liquid, but as the carbon and other elements are expelled from the solidifying wall the central liquid portion continually gains in these elements.

This action continues until the temperature of the liquid portion falls to a point where its consistency becomes so thick that the gas bubbles cannot rise through it, when circulation ceases, gas formation ceases and segregation ceases and the metal inside this zone of gas bubbles solidifies in a mass of comparatively uniform character.

The depth from the outside at which these gas bubbles are held may be varied somewhat by the condition and temperature of the metal when poured, but so far as the author of this article knows they have never been entirely eliminated from standard carbon steels.

They may form in a double line with the first one immediately in contact with the mold, resulting in a bad surface in the product, or they may congregate near the center and form large pockets or a pipe, but like the poor, they are "always with us," in some shape, and the disposition of them as indicated in these charts seems to be the best we can make of them so far.

Chart No. 10, shows what might be expected, viz., that the greatest degree of segregation in the transverse axis of the ingot is adjacent to the zone of gas bubbles, the carbon which was last expelled from the solidified metal being held in the adjoining por-



tion of the central mass of metal which was at the time of too thick consistency to circulate and distribute it, the central vertical axis having less carbon than this gas bubble zone except near the top, as indicated by the charts of tensile strength.

It will be manifest from these experiments that the specimens of plate steel available for testing purposes, which as a rule have

to be taken from shearings from the outer margin of the plates as rolled, show the softest part of the metal, and hence there is in the interior much harder metal, in the case at least of very heavy plates, whether rolled directly from the ingot or from the slab, and in any event there is much larger variation in the character of the metal in a large plate than is usually supposed.

This being the case, coupled with the fact that conditions usually require all or part of the test pieces to be cut from the outside softer portions of the plate, brings about a very risky state of things when, in order to carry high pressure, high tensile strength is specified, because it results in the use of material often so hard in its interior portions as to suffer distress in working to shape and reduces the actual factor of safety in the finished structure.

In the earlier rules adopted by the Philadelphia Department of Public Safety in 1882 for iron plates a factor of safety of five was provided for metal of moderate ductility, but where the ductility was high a factor of safety of four was granted, thus encouraging the use of soft, tough metal.

It would be well if some plan could be adopted now and put into general use which would automatically encourage the use of soft ductile metal, thus securing increased safety to the travelling public and doing away with a lot of difficulty and contention between makers and the inspectors who represent the users of the metal; whose rejection of quantities of material often occurs simply because it falls slightly below the required minimum limit, though this material because of its greater ductility can withstand being worked into the required form for the finished boiler with less risk of weakness developing and is more worthy of carrying the required unit stresses under conditions of service than would be a harder metal of the same thickness.

Under present general engineering practice the working stresses allowable are based entirely upon the minimum tensile strength shown, ductility and maximum tensile being introduced only as a check.

It would be far better I believe if the ductility were introduced as a factor in conjunction with tensile strength to determine the allowable working stresses so that a somewhat lower tensile steel may be used, where it shows a corresponding increase in ductility.

In fact I believe it would result in great improvement over

present practice first to determine the maximum unit stress and then specify the range of tensile stress allowable in the steel coupled with a corresponding proper ductility showing; for instance, given a maximum unit stress of 12,000 pounds per square inch for one class of service specify that the steel shall be allowed a range from 50,000 to 60,000 pounds T. S., provided it also shows a ductility of 1,500,000 pounds divided by the actual T. S. in pounds.

This would result in a factor of safety of five with steel of ordinary ductility, but where the ductility showing is high permit a somewhat less factor of safety, and thus encourage the use of soft steels which, judging from experiences of many years, would result in far greater safety to the public service.

The above suggestions are applicable only to material to be used in tension.

For material to be subjected to compression or to bending (which is a combination of tension and compression) or to alternating stresses or to vibration, different rules would have to be worked out, each adapting to the conditions of service; first, study all that can be learned of the material and conditions of service, and then use "horse sense" in adaptation of material and the adoption of rules to secure the needed qualities in material without imposing unnecessarily difficult or impractical conditions upon manufacturers of the materials, and in the rules establish sufficient elasticity to allow the exercise of reasonable discretion on the part of an intelligent and practical inspector.

We should then all get along better together and secure, I believe, better material without the rejection and waste of a lot of good material, as often occurs under present rules and methods.

Section of Physics and Chemistry.

(Stated meeting held Thursday, February 6, 1908.)

The Electron Theory.

By Edward A. Partridge.

The object of this paper is to set forth the electron theory and to describe briefly its experimental foundations. The theory came into being when it was established that negative electricity is atomic in character; that a negative charge is always a whole number multiple of a definite indivisible quantity of negative electricity. The atom of negative electricity has been named an electron. The first hint that electricity is discontinuous was given by Faraday's work on electrolysis.

To show that in electrolysis equal quantities of electricity are always associated with equal numbers of atoms of a monovalent element and that the ratio between the quantity of electricity passed through a solution and the number of atoms set free is twice as great for a divalent element as for a monovalent element, is to indicate that matter and electricity are similar in constitution.

But Faraday's laws of electrolysis remained for more than fifty years the only statement of fact best explained on the hypothesis of atomic electricity.

Maxwell's far-reaching theory of electricity and its immediate consequence, the electromagnetic theory of light, seemed to fasten attention upon differential equations and to cause men to be satisfied with a mathematical statement of the propagation of a disturbance and not to inquire concerning the nature of electricity. Then, too, the experimental verification by Hertz of Maxwell's theory emphasized its importance. But how unsatisfactory the

theory of electricity seemed to students fifteen years ago. There was little connection between electrostatics and electrolysis, or between electrodynamics and the theory of thermocurrents, and the phenomena of vacuum tubes were but little understood.

It is in this last field that the greatest harvest of truth has been reaped. Sir William Crookes, in 1879, read a paper entitled "Radiant Matter." In that paper he described many of the phenomena caused by what we now call kathode rays. He maintained that the effects he described were due to streams of negatively electrified particles of matter that were shot off from the kathode and by their mechanical energy produced the observed effects. Crookes' view was opposed by the Continental physicists and defended by the English, with the result that the phenomena have been most thoroughly investigated in a long series of brilliant experiments. One of the side results of the work with vacuum tubes was the discovery of Röntgen rays. Finally it has been established that the properties of the kathode rays are independent of the nature of the residual gas in the tube. A kathode ray particle possesses the same mass and the same charge of negative electricity if produced in hydrogen or oxygen, carbon dioxide or helium.

The determination of the velocity and $\frac{e}{m}$; that is, the ratio of charge to mass has been accomplished by extremely ingenious experiments. One method of measuring the velocity and $\frac{e}{m}$ is to determine in the same kathode ray tube, the charge carried in a given time by the kathode rays, the heat developed by their impact, and the deflection of the stream by a magnetic field of known strength. The first of these quantities depends upon the number of particles and the charge on each. The second on the number and the mass and velocity of each. The third on the ratio of charge to mass and the velocity of each. From the equations expressing the actual relations the number of particles can be eliminated and the velocity and $\frac{e}{m}$ found. The velocity under ordinary conditions turns out to be of the order of one-tenth the velocity of light. The ratio $\frac{e}{m}$ is about one thousand times the corresponding ratio for the hydrogen atom in electrolysis. J. J. Thomson, to whom much of this work is due, named the kathode ray particle, a corpuscle. In the interpretation of this ratio we are confronted by two possibilities, either the corpuscle is an atom of hydrogen with a charge one thousand times greater than the charge carried by

the same atom in electrolysis or we are dealing with masses smaller than the hydrogen atom.

The study of radiation, and in particular of the spectra of the elements has for many years rendered familiar the notion that an atom is not an absolute unit, but is a complex, whose parts are capable of vibration within the atom. Iron, for instance, yields a spectrum consisting of hundreds of lines, every one of which corresponds to a vibration within the system that we call an atom. The electromagnetic theory of light teaches us that it is electricity that vibrates in an atom. To account for the series of doublets and triplets in many spectra, Stoney considered the atom as something like a diminutive solar system with the places of the sun and planets taken by minute electric charges. He called these charges electrons. From a consideration of the mutual perturbations of their orbital motions he formed a rational explanation of the existence of the doublets and triplets in spectra.

If the light emitted by a body is due to electrical oscillations within the atom, a magnetic field will modify the period of oscillation. Zeeman, in 1897, discovered this effect. A spectral line is split into two if the light-giving source is placed in a powerful magnetic field and observed along the lines of force; into three, if observed at right angles to the magnetic field. The amount of the separation produced by a field of known strength permits the ratio of charge to mass of the vibrating electron to be calculated. It turns out to be the same as $\frac{e}{m}$ for the kathode rays. When a single spectral line is split into two by looking along the lines of force each component of the magnetically produced doublet is circularly polarized, the circular polarization being in opposite directions. The triplet observed on looking at right angles to the lines of force is characterized by the two lateral components showing plane polarization in planes at right angles to each other, while the central component is unaffected. These polarization effects demonstrate that the lines in a spectrum are produced by vibration of negative electricity.

This is the description of the Zeeman effect in the simplest form as it had been foreseen by Larmor and Lorentz long before it was observed. In addition to this simple phenomenon many lines show a much more complicated behavior, resolving into numerous components when the source is in a powerful field. The vibration frequencies corresponding to lines in spectra have been

shown to be related by a comparatively simple law and have been arranged in series. The Zeeman phenomenon is the same for all the lines belonging to the same series and for the corresponding series in related elements. In a recent paper Jean Bacquerel has shown that the absorption bands in the spectra is xenotim and tysonite are affected in a manner strictly analogous to the splitting up of the lines in emission spectra. Xenotim, a phosphorous compound of yttrium and erbium, and tysonite a flourine compound of cerium, lanthanum and didymium were selected for examination because they possess particularly narrow absorption bands. At the temperature of liquid air the bands become much sharper.

The ratio $\frac{e}{m}$ having been determined by several methods, suggests the measurement of the quantities e and m separately. Here we encounter some most interesting work.

Röentgen rays, radium rays and ultra-violet light ionize air or other gases through which they pass. That is to say, they render the air conducting by forming ions. By measuring the maximum current that a given volume of the gas can carry, the quantity of electricity existing on the charged ions is found. If air saturated with water vapor is suddenly expanded it will be cooled and become supersaturated in the absence of condensation nuclei. Dust particles or gaseous ions serve equally well for condensation nuclei. If saturated air freed from dust by filtration is ionized and expanded the right amount, condensation in minute drops will take place about the negative ions only.

The size of a drop can be calculated from its rate of fall, the total amount of water condensed from the cooling by expansion. So the number of drops, hence the number of condensation nuclei follows as the quotient of the total volume of water condensed divided by the volume of a drop. Knowing the number of nuclei and the amount of electricity existing as charge on ions we have the charge on one ion. The result of the calculation is that the charge on a gaseous ion is the same as on a hydrogen atom in electrolysis. This charge is the same no matter what the gas or the ionizing agency. The final conclusion is that the "m" in the ratio $\frac{e}{m}$ is 1/1000 of the mass of the hydrogen atom.

Hertz found that ultra violet light enabled an electric spark to jump, under conditions that otherwise would permit no spark to pass. Long study has shown that a negatively electrified metal sphere will lose the charge when illuminated by ultra-violet light.

only inertia with which we have to deal. The inertia of a charge at rest is $\frac{2UE^2}{3A}$, according to the calculation of Thomson.

In this formula U is the magnetic permeability of the medium, E is the charge, and A is the radius of the sphere. Since the radius appears in the denominator, the less the radius, the greater the inertia. Consequently, any charge however small may have any inertia however great if we make the radius sufficiently small.

In this connection an additional truth developed by Heaviside and J. J. Thomson is of paramount importance. These men have shown mathematically that the inertia of a charge is not a constant quantity but a variable, that increases with the velocity of the charge. The truth of this statement can be seen almost intuitively, if we remember that an electromagnetic disturbance is propagated with the velocity of light and that therefore the lines of force of a moving charge are not radial as they are when the charge is at rest, but are bent backward approaching the equatorial plane. As a line of force in Maxwell's theory is a line of electric displacement and a varying displacement is an electric current the motion of a line of force in the direction of its length will not produce a magnetic field as there is no current there being no varying displacement. The greater the angle up to 90° between the direction of the lines of force and the direction of motion the greater the magnetic field that is produced. Therefore a variation of velocity when the lines of force are bent backward so as to approach the equator of the moving spherical charge will cause a greater expenditure of energy; the exertion of a greater force, which is the same as overcoming a greater inertia.

The formula expressing the dependence of inertia upon velocity shows that the change in inertia is slight until velocities approaching that of light are reached. In the neighborhood of the velocity of light the increase in inertia is very rapid so that inertia asymptotically approaches infinity with increasing velocity, reaching infinity at the actual light velocity. This deduction from theory has been subjected to experimental test by several experimenters. The first work in this line was with kathode rays, but the velocities are not sufficient to cause changes of inertia much beyond the limits of experimental error. Stark has, however, demonstrated a slight increase of inertia in extremely rapid kathode rays.

The crowning work in this field has been done by Kaufmann, of Göttingen, who has determined the ratio $\frac{e}{m}$ for the β rays of radium by simultaneously observing the deflection produced by electric and magnetic fields of known strength. Rays from a small quantity of radium salt were permitted to pass through a small hole in a piece of lead and then to pass through the electric and magnetic fields maintained in the same space, and finally to fall upon a photographic plate. The difficulty of the experiment can be appreciated by noting that the exposures were of two or three days' duration, and that the electric and magnetic fields had of course to be maintained constant during the entire time. Owing to the fact that β rays from radium are not homogeneous but have very different velocities, the electric and magnetic fields spread them out into a kind of spectrum, each point of which corresponds to a particular velocity. The measurement of the deviations permits the determination of both "m" and the velocity. Kaufmann has demonstrated not only that the mass increases with increasing velocity, but also that the entire mass is due to the charge of electricity that constitutes the particle. From Kaufmann's measurements a judgment is possible concerning the relative probability of the various theories that have been advanced concerning the constitution of the electron. That is, as to whether an electron is a rigid sphere of negative electricity or a sphere that is deformable with change of volume or deformable without change of volume. The conclusion which Kaufmann reached in 1906 was that the rigid electron or the electron that is deformable without change of volume equally satisfy his measurement. To distinguish between them would require a greater accuracy than has hitherto been attained. The whole question as to the possibility of an electron whose shape is not constant arose from the failure to observe any optical phenomenon that is dependent upon the motion of the earth through the ether, provided the source of light is terrestrial. Lorentz has shown that if a contraction takes place in the direction of motion and no change at right angles thereto, that no effect can be perceived by an observer moving with the apparatus. This whole question bristles with difficulties and is still under discussion. This much is certain, the inertia of an electron is all electrical inertia.

Combining this fact with the knowledge derived from the study of the Zeeman effect, that there are electrons in the atoms of mat-

ter, we have strongly suggested that all inertia is electrical. In other words, that atoms are aggregates of electrons.

J. J. Thomson has elaborately worked out the conditions of stability of groups of electrons supposed to be held together by the attraction of an atomic nucleus of positive electricity. He supposes the electrons in an atom to be arranged in rings and to be rotating around a center. He finds that if the number of electrons be increased that the number in a ring may increase to maximum, but that any further increase in the number of electrons will cause the formation of more rings. He shows that atoms built up of electrons whose numbers vary from 59 to 67 show a progressive change in properties, recalling the progressive change in a line of the periodic system of the elements.

This work of J. J. Thomson is the most ambitious attempt to explain the periodic system. Thus far it is merely an analogy.

Our knowledge of the structure of the atom is at the present time almost limited to the results of Stark and his school on the canal rays. Canal rays are observed in the space back of the perforated kathode. They are particles that carry a positive charge of electricity. They have masses of atomic magnitude and so are sharply differentiated from kathode rays, whose particles have masses but 1/1000 that of the hydrogen atom. Canal rays have been observed in many gases. And also the lines in the spectra show the Doppler effect, that is, are displaced in consequence of the motion of the centers of the emission of the light. The Doppler effect in the spectra of canal rays has been observed in the lines of mercury, nitrogen, carbon, oxygen, helium, argon, potassium, sodium, and lithium.

It appears from Stark's work that an atom-residue, positively charged, after having lost a single electron yields a spectrum consisting of series of doublets. If the atom has lost two electrons it emits light, the spectrum of which contains series of triplets. The band spectrum appears to be radiated from the complete atom that is electrically neutral.

From what has been thus far said it would appear that the electron theory has been elaborated to explain certain results of modern experimental physics. The idea has, however, been reached through another channel. Plank by applying general reasoning of the style adopted in thermodynamics and energetics in general to the theory of radiation has deduced the mass of the hydrogen

atom and also the charge that he denominates the elementary quantity of electricity. This determination of Plank of the mass of a hydrogen atom, and the charge constituting an electron, is to my mind one of the most remarkable intellectual results ever achieved. Drude speaks of them as being probably the most accurate values of these constants that we possess.

The fact that no optical phenomenon depending on the motion of the earth through the ether has ever been observed, provided the source of light is terrestrial has lead Einstein to formulate what he calls the principle of relativity. This principle assumes that no such phenomenon is possible. Plank and Stark combined in this principle with the principle of least action and deduced the most remarkable fact that the mass of a body at rest is equal to its internal energy divided by the square of the velocity of light. The smallest inertia with which we are acquainted is that of a single electron. This inertia multiplied by the square of the velocity of light gives us the value of the elementary quantity of energy. Enough has been presented to show how fundamental the electron theory has become and what a wide range of phenomena are correlated by its application. The theory seems destined to play an ever expanding role in the science of physics and gives promise of profoundly influencing philosophic thought.

FELDSPAR DEPOSITS OF MAINE.

The commercially important feldspar deposits of Maine all belong to a single type of rocks known to geologists as pegmatites. These are coarse-grained rocks which as a rule have the composition of granite, their principal constituents being feldspar, quartz, and mica, other minerals occurring in them in subordinate amounts.

Practically all the feldspar mined in Maine is used in pottery manufacture, its main application being as a constituent in both body and glaze in true porcelain, white ware, and vitrified sanitary ware, and of the slip (underglaze) and glaze in so-called "porcelain" sanitary ware and enameled brick. Small amounts of very pure spar, carefully hand-picked, are occasionally shipped for use in the manufacture of artificial teeth. Much interest has recently been aroused in the use of potash feldspar for fertilizing purposes. Experiments by the Agricultural Department have shown that certain plants are capable of readily decomposing feldspar that has been ground to the fineness now usually demanded in the pottery industry (200 mesh and finer), and experiments are now being made by that Department to determine what plants are benefited by the use of feldspar.

In the course of cöoperative investigations between the Maine State

Survey Commission and the United States Geological Survey, E. S. Bastin of the National Survey devoted some time to a study of the Maine pegmatites, and his report on the geographic distribution, geologic occurrence, origin, characters, uses, methods of mining and manufacture, and commercial availability of the feldspar is published by the Survey as part of its annual economic bulletin, No. 315. The principal quarries in Sagadahoc, Androscoggin, and Oxford counties are also briefly described. Numerous other quarries in Maine which have in the past produced feldspar and quartz were visited, and these will be described in the final report on the pegmatitic rocks, new material for which will be collected by Mr. Bastin in the course of his field work this summer. Meantime the paper in Bulletin 315 is available for distribution and can be obtained by applying to the Director of the Survey at Washington, D. C.

ESTIMATING THE COST OF AN ELECTRIC PLANT.

In calculating the cost of an electric power plant, it is of course necessary to take in account the probable life of the plant, so as to make a correct yearly reduction for depreciation. This is often more or less guess work on the part of the constructor or owner, and it may therefore be interesting to see a table from a recent issue of "Zeitschrift des Perines deutscher Ingenieure." The figures given are those used by two English experts, two English public corporations, and to series of figures from German technical publications. Conditions in this country would hardly differ enough from those of Europe as not to make these figures valuable for America.

Years of life for	Robert Hammond.	J. F. C. Snell.	Local Gov't Board.	L. Canby Council.	German.	Numbers.
Buildings	60	60	30	50	66	100-150
Boilers	20	20	15	20	15	10- 15
Steam engines	20-25	25	15-25	20	20	20- 25
Steam turbines	—	—	—	—	20	———
Gas engines	—	—	—	—	17	———
Water turbines	—	—	—	—	22	20 -30
Dynamos	25	25	20	20	20-22	18 -30
Storage batteries	15	10	5-7	20	10	5-10
Transformers	15	20	15	20	—	30
Switch boards	20	20-25	15	20	15	15
Conductors	25-30	15-60	12-15	12-50	25	10 -30
Electric meters	10	15	5	10	—	———
Arc lights	10	15	7-10	—	—	———

W. L.

STRENGTH OF RED AND YELLOW DOUGLAS FIR BRIDGE STRINGERS.

The terms red and yellow fir are not thoroughly defined. By some, only close-grained, bright yellow sticks are designated yellow fir, and all other sticks called red fir; while others call only close-grained sticks of a pronounced red color red fir and all other material yellow fir. Both red and yellow fir are secured from the same species, Douglas fir, and often from the same tree.

An analysis of the strength tests made by the Forest Service on Douglas fir bridge stringers is shown in the attached table. Those stringers were graded according to the export grading rules of the Pacific Coast Lumber Manufacturers' Association, and in the table are grouped by grades. In classifying the stringers according to color all timbers of a reddish tinge were called red fir and all of a yellowish tinge were called yellow fir. The rings per inch shown in the table indicate that yellow fir is of slower growth than red fir. It also ranges higher in grade. Of the 94 yellow fir stringers tested 47.8 per cent. were selects, 40.4 per cent. were merchantables, and 11.8 per cent. seconds. Of the 162 red fir stringers tested 29.8 per cent. were selects, 43.8 per cent. were merchantables, and 26.6 per cent, seconds, but, grade for grade, these tests show that there is practically no difference in the strength and stiffness of red and yellow fir in bridge stringer sizes.

STRENGTH OF RED AND YELLOW DOUGLAS FIR BRIDGE STRINGERS.

(Yellow fir expressed in per cent. of red fir.)

Kind of fir.	Grade.	No. of tests.	Rings per inch.	Per cent. moisture.	Weight per cu. ft. in pounds As tested.	Oven dry.	Fibre stress at elastic limit. Lbs. per sq. in.	Modulus of rupture. Lbs. per sq. in.	Modulus of elasticity. 1,000 Lbs. per sq. in.
Red	Select	48	10.3	29.6	38.2	29.5	4,427	6,974	1,645
Yellow	Select	45*	17.5*	87.0	94.0	97.0	101	96	100
Red	Merch.	71	9.0	29.7	35.9	27.7	4,056	6,019	1,534
Yellow	Merch.	38*	16.4*	90.0	97.0	99.0	101	102	97
Red	Seconds.	43	7.5	27.4	35.7	28.0	3,674	4,923	1,319
Yellow	Sec'ds.	11*	14.5*	98.0	104.0	105.0	99	106	98

*Not expressed in per cent.

—(U. S. Dept. of Agriculture—Forest Service.)

INVESTIGATION OF CENTRIFUGAL PUMPS.

The recent construction of the new Hydraulic Laboratory at the University of Wisconsin has given opportunity for investigation along various lines of hydraulic engineering. The laboratory is located on the shore of Lake Mendota, which furnishes an abundant supply of fresh water. In its construction, two main ideas have been kept in view. First, to construct a laboratory that will give to all students of hydraulics a practical knowledge of the experimental conditions on which the established laws are based, and also a practical knowledge of the actual application of such hydraulic laws. Second, to afford opportunities for advanced students and for hydraulic engineers to undertake research work in lines where the experimental work has been limited or unsatisfactory. With both objects

in view, the construction of the laboratory has been on such lines as will admit of experiments of such magnitude that the unknown factors can be determined with a high degree of certainty, and so that the influence of various changes of condition can be differentiated with a reasonable degree of accuracy.

Among the large number of subjects which have not been satisfactorily covered by past experiments is the subject of centrifugal pumping machinery. This subject has been quite thoroughly discussed from the theoretical side, but most of such discussion has been based on insufficient data, or data which has been too complicated or too greatly obscured by unknown and possibly controlling factors.

The University of Wisconsin, through the department of Hydraulic Engineering, is endeavoring to supply the engineer, manufacturer and user knowledge concerning this type of machinery. The first bulletin on the subject, entitled "Investigation of Centrifugal Pumps. Part I—A Discussion of the Theory of the Centrifugal Pump and Tests of a Six-Inch Vertical Centrifugal Pump," has just been issued by the University.

Referring to the theory of the centrifugal pump, the bulletin discusses the general theory as ordinarily given for deriving the theoretical head developed by the impeller of a centrifugal pump, and shows how the various conflicting formulæ ordinarily given are essentially the same in result.

The experiments with the six-inch vertical centrifugal pump were arranged specially to investigate the effect on the discharge and efficiency, on the number and shape of the vanes of the impeller of the pump. For this purpose the impellers to be compared were made of the same general size so as to be easily placed in the same pump casing, while the number and shape of the vanes used was radial, and radial with curved entrance, while the number of vanes for each shape was varied, being six, twelve and twenty-four in number. The form of water way between the vanes was also varied by increasing the thickness of the outer ends of the vanes. The comparison of the results of the experiments thus show the effect on discharge and efficiency of the pump of practically all possible modifications of the simple radial vane. Additional experiments are now being made which will show the effect on discharge and efficiency of curving the vanes of the impeller both forward and backward, and also of varying the form of the pump casing.

The importance of the subject is such that the investigation has been laid out on broad lines and will last several years. It is hoped that the results of the investigation, when completed, will be of material aid to a thorough understanding of the subject.

The general scope of the investigation has been laid out by Daniel W. Mead, Professor of Hydraulic and Sanitary Engineering, while the details of the investigation and writing of the bulletins have been performed by Mr. C. B. Stewart, C.E. Copies of the first bulletin, University Bulletin, No. 173, may be obtained by addressing the Secretary of the Board of Regents of the University of Wisconsin, Madison, Wisconsin. Price, 50c, post paid, to non-residents of the State of Wisconsin.

FOREST SERVICE REDWOODS OF CALIFORNIA.

The large resources of the Pacific Coast redwood forests have been little used up to the present time. Until recently this timber only has use locally, but now it has become a competitor of many woods in the Eastern markets. It is being much used in the East for shingles instead of cypress, and to some extent for flooring, siding, laths, and finishing work. There is reason now to believe that its field of usefulness as a structural material will become extensive in the East also. Apropos of this situation the following recent letter is significant:

"U. S. Forest Service, Berkeley, Cal.

DEAR SIRS:—We very much desire that the U. S. Forest Service, at its earliest convenience, will make a comprehensive study of the physical and mechanical properties of redwood lumber.

The very many inquiries from parties actively engaged in construction work that are now constantly being made for reliable information concerning redwood, only emphasizes the need of the results of the official study of its properties that we now most respectfully request may be made.

Hoping for your early and favorable consideration, we are,

Very truly,

(Signed) REDWOOD ASSOCIATION,
By A. B. Wilcox.

The Forest Service has decided to comply with the request of the Redwood Association. The work will be done at the testing laboratory at Berkeley, Cal., in cöoperation with the University of California, and it is thought that the results of these tests will prove of great interest to the users of lumber throughout the United States.

A positive charge is not affected. Investigation of this phenomenon has developed the fact that the illuminated body emits electrons and that these electrons ionize the air in the vicinity thereby rendering it conducting. Lenard studied the magnetic deflection of a stream of photo-electrons and measured the ratio $\frac{e}{m}$. Again we find the same value. J. J. Thomson by another method also obtained practically the same result.

In a recent paper Erich Ladenburg has described experiments that demonstrate that the velocity of the projected photo-electrons depends upon the wave length of the ultra-violet light that cause the phenomenon. The velocity increases with the increase of the frequency of the light vibration. This fact adds weight to the hypothesis that the electrons are torn from atoms by electric oscillations that have periods approximately equal to the natural periods of the electrons themselves. The conclusion is plain when we remember that the greater the force retaining an electron in place the shorter would be its natural period, that is, the greater its speed of oscillation and the greater velocity would it have when separated from the atom. In other words, we are dealing with a resonance phenomenon. This view is corroborated in a remarkable manner by a consideration of the optical properties of bodies as worked out by Drude in one of his last works.

Drude was ever on the alert to seize upon any method that promised to yield a clue to the constitution of matter or to reveal a connection between chemical constitution and physical properties. In 1904, Schuster published a paper in which he gave a value for the number of free electrons in metals. Drude immediately took up the idea and greatly developed it, although his results do not agree with Schuster's. The attack proceeds from the theory of dispersion based upon the electromagnetic theory of light as worked out by Helmholtz, Drude, Planck, and Lorentz. For many transparent substances the index of refraction for a wave of given frequency is shown to depend upon the frequencies of the natural vibration proper to the substances. These natural frequencies in the cases of substances having so-called normal dispersion lie far in the ultra-violet or infra-red. The formulæ yield the values $\frac{e}{m}$ for the vibrating matter and also the number of comparatively loosely bound electrons in the molecule.

The value of $\frac{e}{m}$ for the particles having the ultra-violet natural frequency is the same as the same ratio for the kathode rays. The

value for the mass vibrating naturally at the infra-red rate shows that this mass is either a molecule or part of a molecule. In the cases of bodies that show anomalous dispersion the absorption bands are caused by the natural vibration of electrons, not of molecular masses. The importance and certainty of the method is shown by the fact that $\frac{e}{m}$ calculated from the dispersion of hydrogen is 1.5×10^7, while the rate for kathode rays, as determined by Kaufmann, Simon, and Seitz, is 1.86×18^7.

The values of the number of freely movable electrons in a metal as calculated from the optical properties vary from .5 to 7.5 per atom of metal. These numbers agree in general with values to be expected from a consideration of the thermo-electric electromotive forces. The number of conduction electrons, as Drude calls them; in bismuth is particularly small, in antimony particularly great, agreeing with the well-known large thermo-electric electromotive force of a bismuth-antimony couple. Hagen and Rubens have measured the emissivities of a number of metals for very long wave lengths. These numbers permit a calculation of the number of free electrons per cubic centimeter; the results obtained agree well with those derived from a consideration of the optical properties of the metal.

Siertsema has calculated the ratio $\frac{e}{m}$ from the dispersion of the magnetic rotation of the plane of polarized light and obtained a value agreeing well with that reached by other methods.

The electron theory has been applied to explain the electrical properties of metals. This application has been made principally by Drude and Riecke. In solid metals some of the electrons are free and move in the intermolecular spaces according to the laws that govern the motion of the molecules of gases in an enclosed space, and move with an average velocity corresponding to their mass and temperature, *i. e.*, they participate in the motion that is the heat in the body. According to the theory as developed by Drude in its simplest form, the conduction of heat takes place by means of electrons, the molecules being constrained to vibrate about a mean position of equilibrium without collision, while the electrons have the progressive motion ascribed to molecules in the kinetic theory of gases. Electric conduction takes place in consequence of the forward motion between collisions, the forward motion being produced by a constantly acting electric force or difference of potential. The ratio between the conductivities for

heat and electricity turns out to be a constant for all metals and proportional to the absolute temperature. But there are exceptions to this law of Wiedemann and Franz. These exceptions together with the Volta contact differences of potential and thermo-electric electromotive forces compel us to assume that the number of free electrons is dependent upon temperature, and further that the positively charged atomic residues take some part in the conduction of heat and electricity. The greater the deviation from the law of Wiedemann and Franz the greater is the part played by the positively charged atomic residues.

Since the electrons are considered as behaving like the molecules of a gas there will be a definite electronic pressure at a given temperature. Consider a piece of metal whose ends are at different temperatures. The electronic pressure must be the same throughout, therefore the density of the electrons must be less at the place of higher temperature, and we will have a difference of potential between the ends of the piece of metal. The work done by or against the electromotive force and the consequent development of absorption of heat make up the Thomson effect. Contact difference of potential is due to the establishment of equilibrium between different metals that have different numbers of electrons per cubic centimeter.

The electromotive force of a thermo-couple is made up of the electromotive force mentioned in the description of the cause of the Thomson effect and also of the contact electromotive forces of the two metals at the different temperatures. An analysis of the question shows that if the number of electrons in the two metals is independent of the temperature, the thermoelectric electromotive force is proportional to the difference in the temperature between the junctions.

The electron theory of metallic conduction yields a most satisfactory explanation of the Hall effect and the associated phenomena discovered by Nernst, Ettingshausen and Laduc. The Hall effect, discovered at Johns Hopkin in 1878, is the lateral deviation of an electric current that is flowing through a magnetic field. The effect is observed by passing a current through a thin rectangular plate of metal that is between the poles of a powerful magnet. If connection be made to the sides of the plate and the magnet excited, a lateral current is observed. If an electric current were maintained by equal progression of positive and nega-

tive units in opposite directions there would be no Hall effect. For opposite charges moving in opposite directions would be deflected to the same side of the plate. The existence of the Hall effect demonstrates that an electric current consists of a flow that is greater in one direction than the other. The direction of the Hall effect shows that it is the negative electrons that are principally concerned in the phenomena of electric currents. In addition to the Hall effect there are a number of concomitant effects that have been discovered later, there is a difference of temperature developed between the edges and also a longitudinal difference of temperature and difference of potential. There are four entirely analogous phenomena to be observed if a current of heat is passed through the plate that is in a magnetic field. Zahn, in 1904, made an elaborate study of this field and examined his experimental results in the light of Drude's theory. His conclusion was that the theory was well substantiated if the minuteness of the quantities and the experimental difficulties were taken into consideration.

The ratio $\frac{e}{m}$ for an electron has been determined by several distinct methods with practically identical results. Because of the invariability of the properties of kathode rays when the residual gas in a vacuum tube is changed the question arose, "Is the 'm' involved in this ratio, matter in the ordinary sense?" A negative answer to this question has been rendered possible by the following course of reasoning: A charge of electricity possesses inertia. To be explicit: a sphere of metal charged with electricity requires a greater force to produce a given acceleration in it when the sphere is charged than when it is not. This fact was established in a mathematical paper by J. J. Thomson in 1881. A moving charge is an electric current. An electric current is associated with a magnetic field, which possesses a definite amount of energy. A change in the velocity of the charge means a change in the intensity of the magnetic field, that is, a change in the amount of energy stored in the field. To add energy to the field requires work to be done; a force to act through a distance.

We have long been familiar with the idea of self-induction and have illustrated the idea by saying that an electric current acts as if it possessed inertia. In future we shall say, "an electric current possesses inertia." Indeed the idea is fast gaining ground that what was called the quasi-inertia of an electric charge is the